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RECORDS

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GEOLOGICAL SURVEY OF INDIA.

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Portax.
Crocodilus.
Gharialis.
Batagur.
Trionyx.
Emyda.

RECORDS, GEOLOGICAL SURVEY OF INDIA,

Vol. XV, Part 1.

CORRIGENDA.

Page 25, line 2 from bottom, *for* 'in Chutia Nagpur,' *read* 'at Maleri.'
„ 26, „ 7, *for* 'lower,' *read* 'higher.'
„ 45, „ 15, *for* 'microscopically,' *read* 'macroscopically.'
„ 45, „ 15, *for* 'orthoclose,' *read* 'orthoclase.'

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1882. **[May.**

General sketch of the Geology of the Travancore State —*By* W. King, D.Sc., *Deputy Superintendent (Madras), Geological Survey of India.*[1]

My last season's work (1880-81) was devoted to a general examination of the geology of the southern half of Travancore, and to a particular study of a small area of deposits which have been long known as occurring on the sea-coast, on the history of which I have written a separate paper (*infra*).

The development of the gold industry of Southern India having raised hopes of a similar auriferousness of the mountainous and coffee-planting districts in Travancore to that in Wainád, I was, at the very urgent request of the Travancore Government, induced to devote a considerable portion of my time to the examination of the region supposed to present the most favourable indications of gold-bearing rocks. The result of this was a report on the quartz outcrops of Parmand, in which I showed that the supposed reefs are to all appearance beds of nearly pure quartz-rock occurring with the other strata of the gneiss series, and that, though they locally give the very faintest traces of gold, there is no reason to expect that better results will be obtained. Practically, there are no auriferous quartz-reefs, as usually understood, in the area pointed out; neither do I expect that such will be found of any extent or richness in so much of Travancore as I was able to visit.

The geological examination of the country may be said to have extended over more than half of the territory—in reality, it consisted of various traverses over the country between Cape Comorin and the 9° 35′ parallel of north latitude; but I can generalize as to the lie and character of the very few rock formations over the country far to the northward, through visits which I had made in previous years in the Coimbatore and Malabar districts, and this season at Cochin, to which place I was called in connection with a commission of enquiry on the harbours, conducted by Colonel R. H. Sankey, C.B., in the hopes of being able to elucidate something regarding the well-known tracts of smooth-water off the coast at Narrakal and Poracaud.

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[1] See map attached to the following paper on the Warkilli beds.

The Travancore State, though it has long had a very irregular eastern frontier, has now been settled as lying practically to the westward of the main watershed of the southern portion of the great mountainous back-bone or mid-rib of Southern India, which stretches from the low-lying gap of Palghat, below the Nilgiris, to within some 15 miles of Cape Comorin. Between this southern extremity of the mountain land and "The Cape," as it is distinctively called, there is an outlying hill mass which carries the water-shed rather to the eastward of the extreme southern point of India; but a low rocky spur does terminate the and, and outside of it, or a little to the eastward again and somewhat higher, are two rocky islets.

In the northern part of the country the mountain mass is very broad, but just south of the Parmand parallel (the northern limit of my proper work), the hilly back-bone narrows considerably, and becomes a lengthened series of more or less parallel ridges with lower and lower intermediate valleys. These are striking with the gneiss, or about west-north-west and east-south-east, there being at the same time a line of higher masses and peaks culminating the main ridge, from which the ribs run away, as indicated, to the low country.

The mountain land does not, as may be seen by any good map, run down the middle of the peninsula, but keeps to the westward; so that there is a broad stretch of low country on the Madura and Tinnevelly side, while that of Travancore is narrow. Then the mountains drop rather suddenly to the east; while they send long spurs down to within a comparatively short distance of the western coast. There is thus still, in Madura and Tinnevelly, a southerly prolongation of the wide plains of the Carnatic, which stretch round by Cape Comorin and join the narrower, though rather more elevated, low country of Travancore, Cochin, and Malabar.

This narrower and somewhat higher land of the west coast presents also unmistakable traces of a plateau or terraced character, which is best displayed about Trivandrum and northwards past Cochin into the Malabar country. South of Trivandrum these marks gradually disappear, the last trace being in the flat upand or plateau bordering the sea-shore at Kolachel. This more or less even surfaced tract of country has an elevation in its most typical parts of 150 to 200 feet above the sea; and it touches the shore in cliffs or headlands at two or three points, particularly at Warkilli, and in the Paupanchery hill south-west of Trivandrum.

To an observer travelling to Trivandrum across the Ariankow pass from Tinnevelly, the change from the parallel ridges and broken form of the lower hilly country to the comparatively smooth downs of Trivandrum is striking; though he would hardly see the generally terraced or plateau character until a more extended acquaintance had been made with the country.

Northwards from Trivandrum, there are narrow strips of absolutely low land, that is on the sea-level, marked by sandy and alluvial flats and long back-waters or lagoons. These widen out northwards from Quilon, until at Allepy (Aulapolay) there is a width of about 12 miles of such formations, with the very extensive back-water which stretches far past Cochin.

The rock formations are: first, and most prevalent and foundational, the gneiss series; and then on it, but only in a very small way, the *Quilon beds*, which are supposed to be of eocene age. These last are overlapped by the *Warkilli beds*, which certainly appear to belong to a different series, and are thus perhaps of upper tertiary age; they appear also to be equivalent to the Cuddalore sandstones of the Coromandel. Finally, there are the recent deposits.

The gneisses are generally of the massive grey section of the series, that is, they are nearest to the rocks of the Nilgiris, though they differ from them in being coarser-grained or more largely crystallized, and in being generally quartzose rocks.

So quartzose are they, that there are, locally, frequent thin beds of nearly pure quartz-rock which are at times very like reefs of vein-quartz. Often these beds are strongly felspathic, the felspar occurring among the quartz in distinguishable grains, or larger crystalline masses, giving the rock rather a granitic appearance. The only other region where I know of somewhat similar beds of quartz-rock occurring with other gneisses, is in the schistose region of the Nellore district. There, however, the quartz-rock becomes often a fine, compact quartzite; here, in Travancore, there are no approaches to such compact forms.

The common gneisses are felspathic-quartzose varieties of white or grey colours, very largely charged with garnets. A particular form of them is an exceedingly tough, but largely crystallized, dark-grey or greenish felspathic rock.

Massive hornblendic gneisses are not common. Indeed, hornblende may be said to be a comparatively rare constituent of the Travancore gneisses.

All the gneisses are more or less charged with titaniferous iron in minute grains; they are likewise, only more visibly, as a rule, highly garnetiferous. In fact, one might say that Travancore is essentially a country of garnetiferous gneisses. The garnets themselves are only locally obtainable, it being impossible to break them from the living rock, while they are generally decomposed or weathered. They are generally of small size, but are very rich in colour, the precious garnet being very common. Other minerals, such as red, blue, and yellow sapphire and jacinth, are found among the garnet sands so common on the sea-shore at certain places. The sea sands are also full of titaniferous iron grains. While on this subject, I may instance the beautiful and long known constitution of the shore sands at Cape Comorin, where, on the beach, may be seen the strongest coloured streaks or ribbons, of good width, of bright scarlet, black, purple, yellow, and white sands of all these minerals and the ordinary silica.

As will be seen further on, an enormous quantity of ferruginous matter is collected among certain forms of weathered gneiss and other rocks, the source of which is hardly accounted for in the apparent sparse distribution of iron in the gneisses. After all, however, an immense supply of ferruginous matter must result from the weathering of the garnets, when we consider that they are so generally prevalent in all the gneisses, and crowdedly so in very many of them.

The general lie of the gneisses is in two or three parallel folds striking west-north-west to east-south-east. There is, perhaps, rather a tendency of the strike more to the northward in the broad part of the hills, about Parmand, and on towards the Cochin territory. Thus, between Trivandrum and Tinnevelly on the west coast, or for some 12 to 20 miles inland, the dip is high to the south-south-west; inland of the terraced or plateau country, or among the first parallel ridges, there is a north-north-east dip; then, on the mountain zone, there is again a high dip generally to the south-south-west. Thus the inclination of the beds is generally high, right across the strike with a crushed-up condition of the folds; but they are often at a low angle, and the anticlinal on the western, or the synclinal on the eastern side, are plainly distinguishable. About Kurtallam (Courtallum), on the Tinnevelly side, the rise up from the synclinal is very well displayed, and in their strike west-north-westward into the broad mountain land, the beds of this place clearly take part in a further great anticlinal which is displayed in a great flat arch of the Parmand strata. With this widening out of the mountain mass, there is rather an easier lie of the strata.

Southwards from the Ariankow traverse just detailed, there is much crushing up of the beds; but they roll out flatter again towards the southern extremity, and there are good indications of a further synclinal to the south-south-west, in the northerly low dipping beds of Cape Comorin.

Foliation is very strongly developed: indeed it is here, practically, bedding and lamination, of which there are some wonderful exhibitions. At Cape Comorin, indeed, some of the gneiss in its weathered condition (not lateritized) is scarcely to be distinguished, at first, from good thick-bedded and laminated sandstones and flaggy sandstones.

There is no special development of igneous rocks either in the way of granites or greenstones, though small veins and dykes are common, generally running nearly with the strike of the gneiss. In southern Travancore, or north of the parallel of Trivandrum, there are stronger occurrences of granite, in which the mica is abundant and in largish masses.

The great feature about the gneisses in Travancore, and indeed also in Cochin and Malabar, is their extraordinary tendency to weather or decompose generally into white, yellow, or reddish felspathic clayey rocks, which, in many places and often very extensively, ultimately become what is here always called *laterite*. The evidences of this are, after all, only well seen in the field; but it may be stated here that these are seen principally in the constituent minerals, mainly the quartz, being still identifiable in much of the rock—in the lamination or foliation being also traceable—in the gradual change from the massive living-rock to the soft and finally hard, scabrous, and vermicular ferruginous clayey resultant called laterite—and in the thin, pale, and poorly ferruginous form exhibited by the weathering and alteration of the more felspathic and quartzose

This altered form of the weathered gneiss occurs over a definite area which I have laid down approximately in the map. At the same time, the change from unweathered gneiss to this belt is not sharp; for long before the eastern limit of the more generally lateritized belt is reached, approaching it from the mountain zone, the great change has begun.

Very soon after one begins to leave the higher ribs of the mountains, and to enter on the first long slopes leading down to the low country, the gneiss begins to be weathered for some depth into a clayey rock generally of pale colours, streaked and veined with ferruginous matter, and having always an appreciable upper surface of scabrous or pisolitic brown-iron clay, which is, of course, probably largely the result of ferruginous wash and, less so, of ferruginous infiltration. Also, the ferruginous and lateritoid character is developed to a certain extent according to the composition of the gneisses; but, on the whole, there is no doubt that the upper surface generally over large areas is lateritized to a certain depth, irrespective of the varying constitution of the strata.

Then, as the rocks are followed, or crossed, westward, the alteration becomes more frequent, decided, and deeper seated; though still, all over the field, ridges, humps, and bosses of the living rock rise up from the surrounding more or less decomposed low-lying rock areas.

This generally irregular and fitfully altered condition of the gneisses begins at an elevation of about 400 feet above the sea, and thus it extends as a sort of fringe of varying width along the lower slopes of the mountains.

At a yet lower level, say from 200 to 150 feet, and so nearer the sea-coast, there is a better defined belt of more decidedly lateritized form of weathered gneiss, in which the unaltered rock occurs less frequently, and then always in more or less flatly rounded humps and masses, which never rise above a general dead level. This belt is, in fact, a country of undulating downs (where free from thick and lofty jungle), or tolerably uniform level stretches of forest land. Occasionally, it also shows a plateau surface, or it is broken into small and low flat-topped hills. Always it is very deeply indented by river and stream valleys, or even by some of the back-waters which have high and steep shores.

Further northwards, the plateau character of the lateritic gneiss belt is very well developed in Malabar.

It is remarkable of this coastal belt of country that its laterite (an altered, or ferruginously infiltrated condition of weathered or decomposed gneiss) is not to be distinguished from any other laterite, except that which is made up of obviously detrital material.

Whatever the laterite of Travancore or Malabar may have been originally, it is an useless form of the rock, being crumbly and soft as a general rule, and oftener of a red colour than brown. The character of the climate does, in fact, appear to militate against the changing of the red peroxide of iron in the rock, to the brown peroxide, during which change the proper cementing and hardening of the sound rock, such as that on the east coast or in the Deccan, is evidently brought about.

The next succeeding rock formations, namely, the Quilon and Warkilli beds, occur as a very small patch on the coast between the Quilon and Anjengo back-waters.

The Quilon beds are only known through the researches of the late General Cullen, who found them cropping out at the base of the low laterite cliffs edging the back-water of that place, and again in wells which he had dug or deepened for the purpose. I was myself not able to find a trace of them. They are said to be argillaceous limestones, or a kind of dolomite, in which a marine fauna of univalve shells, having an eocene *facies*, was found; and they occur at about 40 feet below the laterite of Quilon, which is really the upper part of the next group.

The Warkilli beds, on the other hand, are clearly seen in the cliffs edging the sea-shore some 12 miles south of Quilon, where they attain a thickness of about 180 feet, and have the following succession in descending order:—

Laterite (with sandstone masses).
Sandy clays (or lithomarge).
Sandy clays (with sandstone bands).
Alum clays.
Lignite beds (with logs of wood, &c.).

The bottom lignite beds rest on loose white sand; and nothing is known of any lower strata.

It will be seen how this set of strata has an upper portion, or capping of laterite, which is however clearly detrital. On the landward edge of the field of those Warkilli beds, there is in places only a thin skin, representative of these upper beds, of lateritic grits and sandstones lying directly on the gneiss, which is itself also lateritized; and it is very hard, as may be supposed, to distinguish the boundary between the two, unless the detrital character of the former deposits is well displayed. Thus, the upper part of the formation has overlapped the gneiss. It is also this upper portion which overlies the Quilon beds, which are also apparently overlapped.

These Warkili beds constitute, for so much of the coast, the seaward edge of the plateau or terraced country above described, and they present similar features. The Warkilli downs are a feature of the country—bare, grass-grown long flat undulations of laterite, with, about Warkilli itself, small plateau hills forming the higher ground—180 to 200 feet above the sea. These downs too and the small plateaus or flat-topped hills, are partly of the Warkilli laterite and partly of the lateritoid gneiss.

Whatever form of denudation may have produced the now much worn terrace of the gneissic portion of the country, the same also determined the general surface of the Warkilli beds. Indeed, it gradually dawned on me while surveying this country, having the remembrance of what I had seen of the plateaus and terraced low-land in Malabar in previous years, that here, clearly, on this western side of India is an old marine terrace, which must be of later date than the Warkilli beds.

These are, as I have endeavoured to show in another paper, of probably upper tertiary age, and equivalent of the Cuddalore sandstones of the Coromandel. Hence this terrace must be late tertiary or post-pliocene, and it marks, like the long stretches of laterite and sandstones on the eastern side of the country, the last great or decided elevation of Southern India, prior to which, as is very probable, the Indian land rose almost directly from the sea by its Western Ghâts and had an eastern shore line which is now indicated very well by the inner edge of the Tanjore, South Arcot, Madras, Nellore, and Godavari belts of laterite and sandstone.

Mr. Foote has already generalised in this way for the eastern side of Southern India in particular; but I think he makes the elevation too great, including, as he does in his laterite deposits, patches of lateritized gravels and rock masses ranging up to a height of 500 feet at least, which are not so definitely part and parcel of the proper coastal developments.

The plateau form of the Coromandel areas has often already been commented on; but their connection with a terraced form of marine denudation is more clearly brought out, now that the evident conformation of the Travancore and Malabar low-land is ascertained.

The somewhat different level of the surfaces of these plateau lands on each side of the peninsula is also interesting in so far as there is an evident general very slight inclination of the whole to the south-eastward.

One more very small patch of variegated sandstones, but associated with scarcely any laterite, occurs in the Travancore country at Nagarcoil, about 12 miles north of Cape Comorin. I should certainly take this to be representative of the Cuddalore sandstones, so long as no positive evidence to the contrary turns up; and it may be the nearest connecting link between these rocks on the eastern coast and the Warkilli beds.

The recent deposits are the usual blown-sands and alluvial deposits of the low flats along the coast; an exceptional form occurs at Cape Comorin in the shape of a hard calcareous sandstone, which is crowded with true fossils and casts of the living *Helix vitata.* It appears to be simply a blown-sand, modified through the infiltration of calcareous waters. Loose blown sands are heaped over it now in places, among which are again thousands and thousands of the dead shells of the past season. The examination of this deposit has, however, been left to Mr. Foote, who has likewise reserved for his study other remarkable fossiliferous rocks of very late age which occur in this neighbourhood.

The Warkilli Beds *and reported associated deposits at* Quilon, *in* Travancore, *by* WILLIAM KING, D.SC., *Deputy Superintendent (Madras), Geological Survey of India (with a map).*

The rocks to be treated of in this paper are some lateritic sandstones, alum clays, and lignite beds, and other fossiliferous strata, which occur in the following order of succession:—

The Warkilli[1] *Beds:* apparently equivalent to the *Cuddalore sandstones* of the survey nomenclature.

The Quilon Beds: reported as having yielded fossils of presumably *eocene* age, and only known through the researches of the late General Cullen.

The Travancore low country, that is, so much of the western coast of southern India, as extends from Cape Comorin to within a short distance of

---

[1] Otherwise Wur-kullay or Varkalay.

Cochin, is slightly elevated and broken into low hills and ill-defined terraced land; thus differing very strongly from the far-stretching plains of the Carnatic, which touch the sea merely by a low bank of sand-hills to nearly as far north as Vizagapatam. At the same time, there is a narrow strip of the northern portion of Travancore which is just on the sea-level, and marked by a chain of extensive and lengthened back-waters or lagoons, the canal communication between which has, until lately, been barred by one small range of low hills between Cochin and Trivandrum. This barrier is the most important of the few approaches of the low terraced upland close on to the sea-shore; and it presents—looking at the absence of such features along the Coromandel, or their rarity along the west coast, the remarkable line of low and beautifully coloured cliffs of Warkilli. This barrier has now, however, been tunnelled so as to allow of complete and unbroken water communication, by which chance fresher sections—though unfortunately not deeper—were displayed of the rocks already so long exposed in the cliffs.

I believe the first idea of thus opening up a complete system of water communication may be attributed to the late General Cullen, then British Resident of Travancore; at any rate, he it was who first drew attention to the geology of this Warkilli barrier, and the occurrence of similar deposits near Quilon. General Cullen did not, it is to be regretted, publish any of his experiences, but he forwarded collections to Bombay, and communicated his observations to Mr. H. J. Carter, then Assistant Surgeon on the Bombay establishment, who embodied them in his well-known "Geological Papers on Western India." The previous literature is therefore, as far as is known, these writings of Mr. Carter; and his conclusions on the occurrence of these rocks, and the fossils said to have been obtained from them, were that they are preferably of eocene age. The following extracts from Mr. Carter's work (*l. c.* p. 741) give the information afforded by General Cullen, beginning with that for Warkilli itself:—

> "The laterite and lignite cliffs of Varkalay, which are also near Quilon, that is, about 12 or 14 miles south, extend along the coast about 6 miles, varying in altitude from 40 to 60 feet. Below the laterite is a series of very beautifully variegated coloured sands and clays, and below them again the carbonaceous clays or shales and lignites. At the north end of the cliffs, where they are only 80 feet high, the lignite bed is level with the beach; but to the south, where the cliffs attain an altitude of 140 feet, there appear to be three or four successive deposits of lignite, each of which is from 4 to 6 or 8 feet thick. To ascertain, also, if this lignite bed extended inland, I sunk a well 20 feet in diameter, at a distance of about 100 yards from the cliff; and, after passing through 22 feet of laterite only (because the well was here sunk in a hollow), came to the lignite clays. I then sunk a small well, about 5 feet in diameter, on one side of the large one, to determine the thickness of the lignite bed, which was penetrated after 7 feet, meeting then with a bed of loose, white sand, from which the water immediately sprung up so rapidly as to oblige the people to leave off working. I have not found any traces of organic remains in these cliffs, nor any traces of limestone. The carbonaceous lignite beds abound with resin and iron pyrites (white), both, in lumps of considerable size. I have a lump of resin 10 inches in diameter.
>
> "The variegated coloured sands that I have spoken of as lying between the laterite and lignite beds, are exceedingly beautiful—at least fifteen different and perfectly distinct tints.

It has strongly reminded me of what I have often heard, but never seen, except in geological drawings, *viz.*, the strata of Alum Bay in the Isle of Wight."

The next place of examination was near Quilon; and it may as well be stated here at once, that I have myself only been able to carry on the uppermost member alone of the Warkilli beds so far north. It will be seen by the next extract (*l. c.* p. 740) that General Cullen was more successful in so far as he found other very important rocks, which were also fossiliferous.

> "The first well I opened was on a laterite cliff or point, 4 or 5 miles north-east of the town of Quilon. Having observed some yellowish slabs of dolomite [argillaceous limestone?] at the base of the cliff or strand of the back-water, which there suddenly deepens to 40 feet, and therefore prevented my tracing it further downwards, I laid open several feet of the face of the cliff, and, still finding the dolomite slabs apparently passing under it, I then went above, for about 100 feet inland, and there sunk a large well, and met with the dolomite at the depth of about 38 feet.
>
> "I then ascertained that the dolomite appeared everywhere to prevail below the laterite round Quilon, at a depth of about 40 feet from the surface.
>
> "This was determined by the examination of wells in different localities, and by further sinking several which had not been carried down to that depth.
>
> "I think there was a loose rubbly bed or stratum, of exactly the same composition as the compact limestone both above and below the slabs, and in which the greater number of the organic remains were found; but the limestone itself (though extremely hard and tough) also contained numerous specimens in the most perfect state of preservation.
>
> "The limestone is of a bluish-grey inside, but externally, where exposed to the weather, of a dull yellowish colour."

This is all that is given of General Cullen's own descriptions; but Mr. Carter subsequently, in his notes, states that further information was furnished in one way or other about these Quilon deposits. Thus (*l. c.*, p. 741)—

> "The specimens of limestone, too, which General Cullen formerly presented to the Society through Dr. Buist, not only bear the colour of the clay, but, with its imbedded tertiary shells, also contain portions of lignite indicating its intimate connection with it."

Again, in his discussion of the fossiliferous evidence of the tertiary deposits of Western India, Mr. Carter writes (*l. c.*, p. 743):—

> "In this structure it will be seen that they resemble *Orbitolites Malabarica*, H. J. C. (Ann. and Mag. Nat. Hist., 2nd Ser., XI, p. 425, 1853), of the blue, clayey, argillaceous limestone of the coast of Travancore[1] · * * ."

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[1] On reference to this paper, I find that the locality of Orbitolites is moved further north, thus: "*Locality*—Abounding in an impure, bluish-green limestone (of the Pleiocene of [*sic*] formations), about 30 feet beneath the surface at Cochin on the Malabar coast, the shells of which, though deprived of their animal matter, are still white and pulverulent, or semi-crystalline." Mr. Carter, who is now residing in England, has very kindly allowed me to communicate with him on the subject of these Travancore fossils, and as regards this variation in locality, writes (7th November 1881):—"As regards the discrepancy in *locality* evidenced in my account of *Orbitolites malabarica*, it should be known that the specimens bearing this *Foram.* came into my hands while I was Conservator of the little museum of the Bombay Asiatic Society, as you may see by the extract, through the late Dr. Buist. This was some time before I began to correspond with General Cullen, and therefore long before I knew anything of the Quilon and Verkallay deposits; so it is not improbable that they, the specimens, were labelled "Cochin." At all events it is a mistake, for which I can offer no other explanation."

And at page 744:—

"Lastly comes the argillaceous limestone of the Malabar coast, not only abundantly charged with the Orbitolite just mentioned, but there again in company with *Strombus Fortisi*, together with *Cerithium rude*, *Ranella bufo*, *Cassis sculpta*, *Voluta jugosa*, *Conus catenulatus*, and *C. marginalus* (Grant, Geol. Cutch, Tert. Foss.); also *Natica*, *Turbo*, *Pleurotoma*, *Fasciolaria*, *Murex*, *Cancellaria*, *Ancillaria*, and *Cyprea*, all (new species?) closely allied in form to the figured shells of the eocene period. The orbitolite differs very little, except in size, from *Orbiculina angulata*, Lam. (Encyclop. Méthodique, pl. 468, fig. 3), from which I infer that the latter should also be included among *Orbitolites*, Lamarck."

I have given the above extracts here, because they go far to show that these fossils, or some of them, are those which were forwarded by General Cullen as having been procured from the beds underlying the Quilon laterite.

General Cullen's description of the occurrence of this "dolomite" and its fossiliferousness is so circumstantial that we must, until better negative evidence than that afforded by my unsuccessful search can be obtained, perforce believe that the rock and the fossils exist as described; hence, I will so consider this deposit in its relations with the Warkilli rocks.

The Warkilli beds consist of a series of sands and clays capped by laterite, giving the range of cliffs touching on the sea-shore. The highest part of the sea-face is at the southern end, between Warkilli village and Naddangúndi (Neddungunday), on the Anjengo back-water. Northwards the high ground runs down with the dip of the rocks, which is very gentle to the north, and thus the range of cliffs soon ceases in that direction until only a low scarped edge of rocks meets the sea at the Parravur[1] (Purra-ur) back-water. Thence, in the same direction, representative strata of the capping beds show only at some distance inland until Quilon is reached, where such rocks approach the shore and form at Tangacheri (Tungumshery) point a very low scarped headland, beyond which out in the sea are barrier reefs of the same rock.

It is not very easy to give the exact limits of the area of the Warkilli rocks, owing to the confusing way in which that peculiar form of rock alteration which gives rise to laterite,[2] or a rock resembling laterite, is developed, not only in these deposits themselves, but in the crystalline rocks or gneisses on which they lie and in the superficial rain-wash and debris covering both. Indeed, an ordinary observer would say, that not only are the Warkilli downs composed of laterite, but that the greater part of the country far inland also consists of the same rock. Practically, there are thus three forms of rock here and in the neighbourhood which usually go by the name of laterite:—

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[1] A peculiarity of the Travancore topography is that there are few well-marked assemblages of dwellings answering to the villages of the eastern side of South India. The names given in the map apply rather to town lands, the cottages or farms being scattered and independent.

[2] The origin of laterite being still unsettled, it is as well that no opportunity should be neglected for keeping certain points in the investigation well to the fore. Only lately, I see that my colleague, Mr. F. R. Mallet, in his paper "On the ferruginous beds associated with the basaltic rocks of North-Eastern Ulster, in relation to Indian laterite" (Records Geol. Surv. of Ind., XIV, p. 148) writes with reference to a generalisation of Mr. W. J. McGee of Farley, Iowa, U. S. A.:—"But that laterite is a product of the alteration *in situ* of the underlying rocks is a view open to serious objections, which has been fully discussed by Mr. Blanford." Now this is striking at actual facts, against which no local or theoretical objections can be taken into consideration: for,—to put it plainly, and as long as we are unable to define strictly what shall and what shall not be called *laterite* among the strange ferruginous rocks which go by that name,—certain forms of this rock are actually and really an altered condition of the rock *in situ*. Such is the case

1. Superficial ferruginously cemented debris.
2. The ferruginous, clayey, reddish or brown coloured, irregularly vesicular and vermiform scabrous rock forming the uppermost portion of the Warkilli beds, which is unmistakably detrital, and which I will call *laterite* in this paper.
3. The altered form of decomposed gneiss (called 'kabuk' in Ceylon), which I shall here write of as *lateritized* gneiss. This form always eventually shows traces of original crystalline structure and constitution.

Owing, then, to similarity of appearance and general ferruginous infiltration of these different rocks, it may be conceived how difficult it is to give close boundaries to the Warkilli beds. There is little trouble about their southern limit; but the eastern boundary is badly defined, it may range a short distance east or west of the line given in the annexed map, and particularly it may be much more sinuous than I have shown, and there may be a few insignificant outliers. About Quilon, I am exceedingly doubtful as to whether a good deal of lateritized gneiss may not be included in my field: thus it would be no easy task for me to persuade any one who had not had great experience of the behaviour of lateritic metamorphosis, that all the lateritic cliffs edging the Quilon backwater are not just as much laterite as those of the portion laid down on the map.

With these qualifications, the Warkilli rocks form a lenticular patch for about 22 miles along the coast, with a breadth, in the middle of the field, of about 5 miles; laterite alone at the Quilon end, and—by their gentle hade up to the south—laterite with underlying beds to a thickness of about 180 feet at the Anjengo end.

The series, as displayed in the cliffs at this end, is in descending order—

	Feet.
Laterite.—Ferruginous clays and sandy clays, in which are occasional, ill-defined masses and bands of coarse sandstone and incoherent sand, more or less vesicular, with irregular hollows and pipe-like or vermiform passages (discontinuous), very many of which are filled with white and pinkish fine clay; brown coloured, shading downwards to red, white, and yellow mottled; banded. Any bedding which may have existed is now much obliterated, and the upper brown band, which is more properly laterite, is not recognisable as a separate bed or capping	30 to 40

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in Travancore, Malabar, and Ceylon, where I have over and over again traced the laterite (as it is called in Travancore) or the 'kabuk' (the Singalese synonym) into the living gneiss rock. I have held this view of what may be called the lateritization of gneiss with Mr. R. Bruce Foote (my colleague in Madras) for the last 20 years: our conclusions having been based on observations on the Nilgiris, Shevaroys, and other elevated regions in the Kurnool and Cuddapah districts; and my enlarged experience of the western coast and Ceylon have only confirmed it. Our experience of the Deccan laterites is not so extended, but we are agreed also that some of these must be products of alteration of the rock *in situ*.

	Feet.
Sands and sandy clays.—Red, yellow, white, and purple variegated sandy clays, with rather more distinct bands and masses of sandstone. Mottled in colour, but not so vesicular as the rock above, though still marbled with vermiform runs of finer clay (lithomarge of some writers). ... about	40
Pale red and white variegated and laminated sandy clays ...	10
Alum Clays.—Dark-coloured purple grey, compact clays with thin, scarcely appreciable, laminæ of iron pyrites; giving bright yellow alum efflorescence	5
Various coloured alum clays and sands; dark grey and buff at the bottom and yellow towards the top	20
Lignite beds.—An incoherent sandy bed of varying thickness, much laminated with brown loamy and clayey material, in which are many lumps and even logs of wood in various conditions of preservation. The wood is mostly blackened, and much in the condition of the 'bog-oak' of the Irish peat bogs	2 to 10
Dark, nearly black, clay; often rather peaty, or having patches of fine black vegetable matter, with particles and small masses of iron pyrites; containing, here and there, big logs of spongy, rotten, and, as it were, charred wood, and lumps of coarse resin . . . . about	5
Loose sands.—Coarse and white-coloured; only a few inches exposed.	

Thus, for the sea-cliffs, the section is in general terms:—

	Feet.
Laterite	30 to 40
Sands and sandy clays, or lithomarge	58
Alum clays	25
Lignite beds	7 to 15
Sands	...
Total .	120 138

Strong springs of clear fresh water issue at several points along the base of the cliffs from above the alum clay band. These are supposed to possess curative properties, and are accordingly of frequent resort.

The sections exposed in the cuttings and tunnelling of the barrier, which lie from a few hundred yards to half a mile inland, give a thickness of 30 to 70 feet for the laterite. This shades down into red, yellow, and whitish clayey sandstones, which are generally soft and wet, though at times hardened in bands and patches, and which have a variable thickness of from 40 to 90 feet owing to a wavy and uneven bottom. The alum clays are beautifully exposed in good beds, and for a long time they presented a fine display of colours—reds, blues, and greys, with strong bright yellow efflorescence, which have now, however, become blurred through exposure. In their lower sandy portion there is a good deal of wood. The thickness of the alum beds is about 20 feet. The proper lignite seam has about the same thickness as on the shore; but as the base of the tunnel does not run below them, there is no knowledge of the subjacent rock.

The outer and inner sections are thus substantially the same,—the differences being that the beds below the laterite, in the cuttings, are rather clayey sandstones than sandy clays; while logs of wood are found in the alum clays also.

As these beds are followed northwards along the shore, the dip gradually carries the lignite band below the beach, which is next bordered, for some hundred yards, by the alum clays, the upper edge of which is marked by the bamboo spouts let in above them at convenient places for carrying off the water of the sacred springs.[1] Then the clays, in their turn, run under a long flat beach, over which the water of the springs now flows directly, and about a quarter of a mile further on, the lowering cliffs are simply of the laterite, which rock finally ceases to show on the shore near Purravur.

The Warkilli capping is, however, continued inland in a north-eastward direction to the narrowing of the Purravur lagoon at Mailakád (Mylaked), but here all that exists of it is a very thin skin of coarse ferruginous grits and sandstones, which is lying directly on weathered and lateritized gneiss, the lower portions having thus been overlapped. Hence, if the clays, &c., are continued northward, they must lie deep under the lagoon and the sea.

From Mailakád other sandstone outcrops, associated with laterite, are traceable up to Quilon, under which place it might naturally be expected that either some trace of the Warkilli beds should be found, or that the laterite should overlie the gneiss directly. The only deposits, however, which I could find differing from the prevalent laterite, or its underlying lithomarge (common at the base of the low cliffs edging the back-water) is a loose, very coarse, yellow sand, occurring in a dried-up stream bed, or wide ditch, near the mosque between the civil town and the parade-ground, which is like some of the loose sands below the laterite band at Warkilli. I saw no limestone[2] or other calcareous rock answering to that described so circumstantially by General Cullen as cropping out at the base of the low cliffs north-east of Quilon.

Only representatives therefore of the upper portions of the Warkilli beds occur at Quilon resting upon and apparently overlapping a set of fossiliferous beds only known through the researches of General Cullen.

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[1] The water seam supplying the springs on the sea-shore was tapped by the tunnel operations, and there was a slight temporary decrease in the discharge. The leaking of the water in the tunnels and at the cuttings over the freshly opened alum clays, and the mixture of ferruginous wash from above, thus gave rise to considerable surmise as to the existence of natural chalybreate and other waters. Such are, however, only produced temporarily, though they will be collecting for a long time, and they might be found efficacious in some cases of the skin diseases so common on this coast.

[2] This reported occurrence of limestone and fossils by General Cullen is one of the strangest incidents of recorded observation which has taken place in India; for his account of it, and of his reasons for concluding that such a deposit underlies the Quilon laterite, is so clear that one can hardly suppose him to be mistaken; and yet there is no other evidence of its occurrence than the general statement as given by Dr. Carter. Not only have I not been able to find it, or the least trace of any calcareous debris—itself a very strange thing when we recollect that wells had been sunk inland—but the same disappointment had been already experienced by the District Engineer, Mr. Horsley, who is perfectly capable of distinguishing a calcareous rock, and, under the very urgent requirement of the works at Quilon for mortar, most diligent search for this argillaceous limestone or dolomite had been made. I believe, also, that Mr. Horseley had the advantage of employing the only guide left in a servant at the Residency, who used to accompany General Cullen in his excursions, and to work for him. This man, unfortunately for me, was at the time of my visit paralysed in his speech through continued fever and rheumatism, or other ailments, and unable to be moved.

The Warkilli strata are clearly of fresh-water or lagoon origin, being in fact very much after the style of the deposits now being laid down in parts of the present back-waters into which, at flood times, a great deal of drift wood and decaying vegetable matter is being carried along with silt clays and sands and ferruginous matter.

The fossiliferous argillaceous limestones under the laterite at Quilon are apparently very thin; and as the fossils described as having been obtained from them constitute an essentially marine fauna, they can hardly be considered otherwise than as belonging to a separate and somewhat older group than that which has thinned out over them. Each of them may be groups of a series or of a formation, or they may not; but the important feature is that they are separate groups; and thus I would differentiate the Quilon beds.

Reference to the "Geological Papers on Western India" already quoted will show how the whole series of Travancore deposits has been correlated with very similar deposits on other parts of the coasts of the Peninsula; as on this side going northwards, at Ratnagiri, Bombay, Broach, Kattiwar, Cutch, and Sind, and, on the other side, through the sandstones and laterite of the Coromandel, and the fossiliferous intertrappean beds near Rajahmundry. This correlation went too far, however, partly through this separate grouping not being known, and by a very natural straining at the comparison of a series of laterite and fossiliferous beds with the lateritic beds and limestones of Rajahmundry, which last now appear to be most reasonably of upper cretaceous age[1]: while the fossiliferous beds of Bombay northwards are of tertiary age.

Mr. Carter's correlation of the Quilon fossils with those of the Kattiwar, Cutch, and Sind beds, still stands, however, and he thus makes them out to be preferably of eocene age.

The Warkilli beds must then be either of the same age, or, if different conditions of deposition and apparent overlap go for anything, of perhaps a later tertiary age.

The evidence given by the wood at the base of the alum clays and in the lignite seam, is of little significance considering that perfectly fossilised wood occurs in the older alluvial deposits of the Godávari valley, which certainly appear to be far later deposits than these; though the very unaltered condition of the logs implies that they must be much newer than those containing the perfectly bleached and dull shells said to have been obtained from the Quilon diggings. To all appearance, indeed, this wood is very like the black-wood now growing in the Travancore forests; and it is so unaltered in good specimens that large pieces of furniture have been made from it which are scarcely distinguishable from that made out of the modern timber.

Again, taking up the original generalisation of Carter and other observers, but leaving the intertrappean beds of Rajahmundry out of count, there does not appear, so far as is yet known, to be any representative of the Quilon beds on the Coromandel, at least as far south as Madura. On the other hand, there is a strong lithological likeness between the upper portion of the Warkilli beds and the upper portion of the Cuddalore sandstones as at Vellum, in Tanjore, in the Red Hills of Pondicherry and Madras, and in the Nellore and Godávari districts; while they are all similarly situated as low-lying or not very elevated fringes bordering the sea-coast. There is also a possible link to this chain of coastal deposits on either side of India, in a small patch of red and variegated sandstones, with, however, very little show of laterite at Nagercoil, about 12 miles north of Cape Comorin.

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[1] See Memoirs Geological Survey of India, XVI, pt. 3, and Manual of the Geology of India, Chapters XIII & XIV.

Irrespective, however, of any argument from the association of the Warkilli laterite and sands with fossiliferous limestone having eocene affinities, a generally tertiary age has been given by us to the Cuddalore sandstones, through their discordant lie on the cretaceous rocks in South Arcot and on the traps and intertrappean beds of Rajahmundry. Hence, on the ground of lithological likeness, similarity of position, and, as far as it goes, general approximation of age, it may be assumed that the long supposed contemporaniety of the coastal laterite and sandstones is now fairly made out. Thus, as they are so continuously developed over large areas and occur in detached positions over so lengthened a coast line, without apparently being accompanied by or associated with these strange Quilon rocks, except in this one locality, they are indeed strongly separable from the latter and thus presumably of much later, or even upper, tertiary age.

I have had opportunities in previous years, and this season again, of examining the West Coast for some considerable distance further north, past Cochin and on to a few miles beyond Calicut; but so far there is no further representative of the Warkilli beds in particular, or the Cuddalore sandstones in general. It is quite true, however, that there are very extensive tracts of what is called laterite, as well as a remarkable terraced and plateau form presented by many of the low hills of these tracts. My examination of these showed, however, that all this lateritic country is merely one of a decomposed form of gneiss, and that the capped character of the plateaus in the neighbourhood of Beypur and Calicut, for instance, is due to the denudation of an originally planed-down terrace of gneiss into detached plateaus, the upper surfaces of which are altered and lateritized to a certain depth.

There may be detached patches of the Warkilli beds north of Calicut as yet unknown, but the first occurrence of rocks resembling them, of which there is any record, is in the neighbourhood of Ratnagiri, of which the following section is given by Dr. de Crespigny (1856)[1]:—

"Soil and detrital conglomerate	(a few feet).	
Laterite (soft below)	35	ft.
Compact iron stone	1½	„
Lignite	27	„
Blue clay		
Water, yellow gravel		
Trap."		

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[1] Carter's Papers, *op. cit.* p 722, foot note.

Mr. C. J. Wilkinson, when attached to the Survey (in 1863), visited this part of the country, and thus describes[1] tho occurrence of these rocks:—

> "At Ratnagherry, &c., in well and other sections, the trap is found to be overlaid by a thickness of a few feet of white clay, imbedding fruits and containing thin carbonaceous seams composed for the most part of leaves. This is separated from the soft laterite above by a ferruginous band about an inch thick, having much the appearance of hæmatite. It is vesicular, the cavities being filled by quartz, &c. The soft laterite soil above hardens on exposure, and this rapidly. It is very thick here and along the sea coast, trap only becoming exposed in the deep sections and at the base of the cliffs."

It cannot, I think, be doubted that here is a true representative of the Warkilli beds; and as the traps on which the rocks lie are generally flat, it is not to be expected that any representative of the Quilon beds shall be found.

Note on some Siwalik *and* Narbada Fossils *by* R. LYDEKKER, B.A., F.Z.S., *Geological Survey of India.*

1. *The Narbada Hippopotamus.*

In Falconer and Cautley's great work on the fossils of the Siwaliks, there are figured numerous remains of hippopotami from the pleistocene deposits of the Narbada valley. Among these remains all are referred to a species named *Hippopotamus palæindicus*, with the exception of four lower jaws,[2] which are referred to a second species under the name of *H. namadicus*. Unfortunately neither of these species was ever described, so we are compelled to rely upon Falconer's figures and occasional notes. It is stated[3] that *H. palæindicus* is allied to the living African hippopotamus, but is distinguished by the median pair of incisors being slightly smaller than the outer; the reverse being very markedly the case in the living species. This species had only two pairs of lower incisors, and was accordingly referred to Falconer's sub-genus *Tetraprotodon*. These teeth are of large size.

In *H. namadicus*, which, as already said, is known only by the lower jaw, there are always six incisors, which in some specimens (F. A. S., pl. LVIII, figs. 1, 3,) are sub-equal in size, and placed in the same horizontal line; while in others (*Ibid*, pl. LVII, fig. 12; LVIII, fig. 2), the second pair of incisors is rather smaller than the others, and thrust somewhat above their line. All the incisors of this form are smaller than those of the tetraprotodont form.

If no other specimens than those figured in the "Fauna Antiqua Sivalensis" were in existence, I should have little, if any, doubt as to there being two species of Narbada hippopotami. There are, however, two specimens of the mandibles of hippopotami in the Indian Museum, from the Narbada deposits, which lead me to have very grave doubts on this subject.

The first of these specimens (F. 147) has three pairs of incisors of sub-equal size, and must therefore be referred to Falconer's *H. namadicus*. The second

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[1] Records G. S. of Ind., IV, p. 44.

[2] Pl. LVII, fig. 12; LVIII, figs. 1, 2, 3.

[3] "Pal. Mem." Vol I, pp. 21, 147, 497.

pair of incisors are, however, more raised above the line of the others than in any of Falconer's specimens.

The second specimen (F. 148) has two pairs of very large and closely approximated incisors, and therefore agrees with Falconer's *H. palæindicus.* In the upper angles between these large teeth, there are, however, wedged in, two very minute teeth, corresponding to the second pair of incisors in *H. namadicus.* The vertical diameters of the first, second, and third incisors in this jaw are respectively 1·96, 0·59, and 2·0 inches; while in the other specimen they are 1·2, 0 9, and 1·33 inches. The specimen No. F 148 must certainly be referred to *H. palæindicus,* but the presence of the minute pair of second incisors connects it so closely with those forms of *H. namadicus* in which that pair of teeth is, so to speak, partly squeezed out of the way by the others, that it becomes a question whether the latter species can be maintained.

It is true that in the typical tetraprotodont forms, and in No F 18, the first and third incisors are much larger than in typical hexaprotodont forms; but this might be accounted for by the greater space for growth which these teeth obtain in the tetraprotodont form.

On the whole, it would perhaps be rash to say positively that there is only one species of Narbada hippopotamus; but, taking into account that only one form of skull could be distinguished by Dr. Falconer, and the variations above noticed in the lower incisors, such was not improbably the case.

The tetraprotodont form of the Narbada hippopotamus seems to be distinguished from the African species by having the two pairs of incisors of sub-equal size, or the outer larger than the inner. In the living species the inner incisors are generally very much larger than the outer. The hexaprotodont form in which the lower incisors are of sub-equal size, and placed in the same horizontal line, seems to agree very closely with the older *H. sivalensis,* and I am not aware how they can be distinguished.

The Narbada hippopotamus, whether belonging to one or more species, shows a clear instance of the evolution of a tetraprotodont from a hexaprotodont form, after the general law of progression from the generalised to the specialised. These animals, further, most clearly connect the Siwalik with the living form, and may thus indicate the line of descent of the latter.

The above conclusions indicate decisively that Falconer's sub-genera *Hexaprotodon* and *Tetraprotodon* must be abolished, as their distinctive characters are found in the same species. They further indicate that it is almost certainly the second pair of incisors which is suppressed in the African hippopotamus; a fact which may prove of some importance in determining the homologies of the incisors in other ungulate mammals (*e.g.*, *Rhinoceros*) in which the whole of the typical series is not developed.

2. *Structure of molars of Mastodon sivalensis.*

A much worn molar tooth of *Mastodon sivalensis* from the Punjab in the collection of the Indian Museum,[1] which has been recently cut and polished, shows a peculiarity in the arrangement of the enamel, not previously observed, as far as I am aware, in the teeth of the Proboscidia. The enamel, in place of simply investing the cones, or denticles of the crown, as a regular cap, is thrown into numerous folds, placed at regular intervals from one another, penetrating deeply into the dentine of the cones, and converging towards their centres. The horizontal section of one of these cones exhibits a structure intermediate in respect to the depth of the foldings of the enamel, between that of the teeth of *Ichthyosaurus* and *Labyrinthodon.*[1] The infoldings are considerably deeper than those in the former genus, and if the symmetry of the cones were not interfered with by mutual adpressure, these infoldings would present a regular convergence towards the centre as in *Ichthyosaurus.* A second cut specimen exhibits a similar structure.

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[1] No. A. 258.

I have not observed this structure in the molars of any other species of mastodon; and from the statement of Professor Owen, that "there is no instance in the mammiferous class of these [enamel] folds converging at regular intervals all round the circumference towards its centre,"[2] it would appear that the molars of *Mastodon sivalensis* are quite peculiar in this respect, and exhibit a homology between the teeth of mammals and reptiles not previously known to exist.

3. *Captain Searle's Perim Fossils.*

A small collection of vertebrate fossils from Perim Island, collected by the late Dr. Wilson, has recently been presented to the Indian Museum by Captain Searle, Superintendent of Marine, Calcutta, which may be appropriately noticed here. The collection comprises a tooth of *Mastodon perimensis,* and a broken one of *M. latidens.* A lower jaw of *Acerotherium perimense,* and one of another member of the same family, showing the symphysis, and identical with the mandible referred to *Rhinoceros sivalensis* in the "Palæontologia Indica":[3] this form is new to Perim Island. Several limb-bones of elephants and rhinoceroses are also among the collection. There is a horn-core of a large ruminant, generically indeterminable. There are also two fine specimens of the cranium of *Gharialis gangeticus,* and the imperfect humerus of a large species of tortoise (not *Colossochelys*), new to these deposits.

With these additions the fossil vertebrate fauna of Perim Island includes the following forms[4] :—

Mastodon latidens, Clift.
  „ perimensis, Falc. and Caut.
  „ pandionis, Falc.
Dinotherium indicum, Falc.
Hyotherium, sp.
Sus hysudricus, Falc. and Caut.
Bramatherium perimense, Falc.
Camelopardalis sivalensis, Falc. and Caut.

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[1] See Owen's "Odontography," pl. LXIV B.

[2] *Loc. cit.,* p. 201.

[3] Series X, Vol. II, pt. I.

[4] This list may be taken to supersede that given on page 343 of the "Manual."

Antilope, sp., and other ruminants.
Capra perimensis, Lyd.
? Rhinoceros sivalensis, Falc. and Caut.
Acerotherium perimense, Falc. and Caut.
Hippotherium theobaldi, Lyd.
Crocodilus palustris, Less.
Gharialis gangeticus, Gmel.
Colossochelys atlas, Falc. and Caut.
Testudo, sp.
Emyda, sp.
Trionyx, sp.

4. BAGARIUS YARRELLI, *from the Siwaliks.*

In the sixth volume of the "Journal of the Asiatic Society of Bengal"[1] a portion of a fossil ichthyopsidan skull is described and figured by Dr. Cantor as that of a gigantic batrachian. It was discovered by Colonel Colvin in the Siwaliks of Náhan, and is now in the collection of the Indian Museum.[2] In 1844 this specimen was again described and figured by Dr. M'Clelland,[3] who showed that it belonged to a siluroid fish, and probably to *Pimelodus.*

At a subsequent date reference was made by myself to the specimen,[4] when it was argued that it was improbable that it belonged to *Pimelodus,* since that genus is confined to the West Indies and Africa. In Dr. M'Clelland's time, however, the genus was less strictly defined and comprehended many Indian forms, and it will be shown below, that in this wider sense Dr. M'Clelland's determination was correct. It was suggested in my notice that the specimen might belong to the genus *Chaca.*[5]

Thus the matter remained till a few weeks ago, when a huge siluroid, caught in the Hughli, was brought to the Indian Museum by its captors. On seeing this gigantic fish I was at once struck with the resemblance of its head to the fossil skull, and accordingly made arrangements for comparing the two skulls as soon as the recent fish was macerated. This comparison I have lately made, and I find that the fossil (of which Dr. Cantor's figure gives a very good idea) comprehends the preorbital part of the skull and agrees precisely in every detail, both of shape and size, with the skull of the recent fish. The agreement between the two is so close that I have no doubt but that they are specifically identical.

An examination of the recent fish shows it to be *Bagarius yarrelli,* Sykes, which according to Dr. Day,[6] inhabits "the large rivers of India and Java, descending to their estuaries. It attains 6 feet or more in length." The present specimen was just under 7 feet in length. The old name of this fish was *Pimelodus bagarius.* The identity in size of the recent and fossil skulls probably indicates that the two specimens had attained the full development of which the species is capable. The extreme length of the recent skull is 21·4 inches.

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[1] P. 538, pl. XXXI.

[2] No. E, 155.

[3] "Calcutta Journal of Natural History," Vol. IV, p. 83, pl. IX.

[4] Journal of Asiatic Society of Bengal, Vol. XLIX, pt. II, p. 15.

[5] This suggestion was mainly made on the supposition that the fragment of the skull was more complete than it is, and consequently that the skull was very broad and short.

[6] "The Fishes of India," Vol. II, p. 495, pl. CXV, fig. 3.

The determination of another existing species of vertebrata in the Siwalik fauna is a matter of extreme interest, and confirms the inferences previously drawn as to the geological age of this fauna. The living species now identified from the Siwaliks are *Crocodilus palustris, Gharialis gangeticus, Pangshura tectum, Emyda vittata,* and *Bagarius yarrelli.* We shall see below that *Python molurus* may not improbably be added to this list.

5. *The Siwalik Python.*

On page 20 of my paper in the "Journal of the Asiatic Society of Bengal" already quoted, reference was made to some ophidian vertebræ in the Indian Museum[1] from the Siwaliks of Sind and the Punjab, which were said to resemble those of *Python.* I have lately submitted these vertebræ to a careful comparison with those of the living Indian *P. molurus,* and can detect no difference between the two. Most of the fossil vertebræ belonged to pythons of not more than 5 or 6 feet in length, but an early dorsal [2] indicates an animal of upwards of 15 or 16 feet in length. It would, perhaps, be rash to say positively, from the evidence of these vertebræ, that the Siwalik python was specifically identical with *P. molurus,* but it is quite probable that such was really the case.

6. NARBADA AND SIWALIK MOLLUSCA.

Mr. Geoffrey Nevill, our specialist on Indian terrestrial mollusca, has been kind enough to examine the small collection of land and fresh-water shells from the pleistocene of the Narbada and Jamna, and also from the Siwaliks, contained in the Indian Museum. It may be observed that lists of shells from the Narbada beds have already been published by Mr. Theobald in two separate papers,[3] and that the specimens mentioned in the second of these papers are those submitted to Mr. Nevill, whose determinations differ somewhat from those of Mr. Theobald. Of Siwalik shells the Indian Museum has but three species.

A note on shells from these deposits is given in the "Palæontological Memoirs,"[4] but the knowledge of living Indian terrestrial mollusca was then so imperfect that the note is practically valueless. It would appear from this note that a considerable variety of Siwalik shells were obtained, which are probably now in the British Museum, and it is much to be desired that they should be submitted to the examination of some competent authority for determination.

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[1] Nos. E205-206.

[2] No. E 206.

[3] Mem. Geol. Surv. India, Vol. II, p. 284, *et seq.* *Supra,* Vol. VI, p. 54, *et seq.*

[4] Vol. I, p. 389.

The shells from the Jamna pleistocene mentioned in the following list were collected, and presented to the Indian Museum by Mr. John Cockburn :—

Name.	Narbada.	Jamna.	Siwalik.	REMARKS.
Melania tuberculata, Mül., v. pyramis, Bens.	+	+	...	
Planorbis compressus, Bens. . . .	+	...	...	
„ convexiusculus, Hut. . . .	+	...	...	
„ exustus, Desh — ? var. . .	+	...	...	
Paludina bengalensis, Lam. . . .	+	...	...	
„ dissimilis, Mul.	+	+	...	
Helix proxima, Eish	+	...	...	
„ asperella, Pfr.	+	...	...	
Buliminus (Cylindrus) insularis, Ehr. . .	+	...	+	
Corbicula, sp. 1	+	...	...	Referred by Mr. Theobald to *C. cor.*
„ „ 2	+	...	...	Very small, with large ridges.
„ „ 3	...	...	+	Large: Mr. Nevill cannot identify with any living form.
Unio marginalis, Lam.	+	...	+	
„ favidens, Bens., var. 1	...	+	...	Near *U. marcens*, but cannot be identified with any living variety.
„ „ „ var. 2	+	...	...	Near *U. wynegangensis*, Lea.
„ „ „ var. 3	..	+	...	Near *U. triembolus*, Bens.
„ wynegangensis, Lea . . .	+	...	...	
„ shurtlefianus, Lea	+	...	...	
„ indicus, Sow., var.	...	+	...	
„ macilentus, Bens., var.	+	...	...	
„ corrugatus, Mül., var. . . .	...	...	...	

The most important fact to be gleaned from this list is that two species, *viz.*, *Buliminus insularis* and *Unio marginalis*, can be traced without variation from the Siwaliks, through the Narbada to the present time: both are still living in the Narbada valley. A Siwalik species of *Corbicula* is considered by Mr. Nevill to be probably extinct, while a probable variety of *Unio favidens* from the Jamna seems to differ from any living variety, though great stress cannot be laid on this point owing to the uncertainty of the specific character of the members of this genus.

7. GIGANTIC HYOPOTAMUS, *from Sind.*

From the lower Manchhars of the Bhugti hills, north of Sind, Mr. W. T. Blanford has lately procured some upper and lower molars of a gigantic species of *Hyopotamus*. These teeth are far larger than those of any described species, nearly equaling in size the molars of *Anthracotherium magnum*. They will be described subsequently in the " Palæontologia Indica."

On the Coal-bearing rocks *of the valleys of the upper* Rer *and the* Mand *rivers in Western Chutia Nagpur.* (*With a map.*)

By V. BALL, M.A., F.G.S., *Geological Survey of India.*

The following is a record of observations made in the season 1870-71 during a traverse of the areas of coal measures which intervene between those of the Bisrampur field on the north and the Raigarh and Hingir coal-field on the south. Fuller and more detailed examination of these last mentioned fields in subsequent seasons enabled separate accounts of them to be published,[1] but as the details, now about to be given, were of incompleted areas, their publication was held over until such time as the whole area between Raigarh and Korba could be thoroughly explored and described as a united coal-field. Except a brief summary in the Manual of Geology[2] taken from the following notes, nothing has been published regarding these areas, so that in view of the present importance attaching to the existence of coal in this region and in anticipation of future more detailed work, it is thought that the following instalment of information may be of value as it serves to link together the coal measures of Sambalpur, Central Sirguja, and Korba, in Bilaspur.

Lakhanpur Field.

This field, as at present known, is a small area of about 50 square miles, situated in the south-west corner of central Sirguja and to the south of the Pilka hills.

On the north it is bounded by the Pilka fault, described in the Bisrampur report; on the north-east by metamorphic rocks, the boundary being probably natural. On the south-east also by metamorphic rocks, the boundary being here faulted; on the south partly by metamorphic rocks and partly by Talchirs which connect it with the Rampur field. The western extension has not yet been examined.

Within the limits of this area there are no hills; a thick covering of alluvium obscures all the rocks except in the river sections, of which, however, there are fortunately a good many.

The rivers are the Rer or Arand and the Goinghata with 5 or 6 direct and indirect tributaries, all of which afford sections.

The rocks exposed all belong either to the Talchir or Barakar groups, there being no representative of the upper sandstones found in this area.

TALCHIRS.—A strip of Talchirs, not very distinctly seen, occurs on the north-east boundary of the Barakars; the only clear section of these rocks occurs in the Goinghata west of the Satpara and Mendra road; they consist there of green sandstones, shales, and the boulder bed.

Some Talchir rocks are also exposed in the bed of the Goinghata near the deserted village of Rukra, their relationship to the Barakars on the north and south I had not time to ascertain.

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[1] Raigarh and Hingir, Rec. Geol. Surv. of India, Vol. IV, pp. 101 to 107; Vol. VIII, pp. 102 to 121, Vol. X, pp. 170 to 173, Bisrampur *op. cit.* Vol. VI, pp. 25 to 41.

[2] Part I, p. 207.

In the Rer or Arand on the south-west, Talchirs crop up, and passing southwards connect this field with the one further south (Rampur), which is traversed by the higher reaches of the same river.

In the jungle near the village of Mudesa, east of this field a small outlier of Talchirs was noted. Its limits were not traced out.

BARAKARS, *Goinghata section.*—North-east of Mahadeopara there are some slates and quartzites apparently of sub-metamorphic age. South of these there is an interval through which the fault, already mentioned, probably passes. Nearly east of the village there are Barakar sandstones which include a seam of carbonaceous shale, and from under which the Talchir rocks, just alluded to, crop out and continue in the bed of the stream for about half a mile, after which they are again covered by apparently the same section of Barakars.

The repeated seam appears to contain a small quantity of poor coal, after which there are two seams which contain carbonaceous shale only. In the reach north-west of Parsori there is a seam containing about 3 feet of stony but burnable coal. The base is hidden. North of Ambera there is a seam badly seen in the bed of the river; it contains at least 2′ 4″ of tolerable coal.

South of the mouth of the Khekra stream the only rocks which are exposed are sandstones and grits, save a very fine trap dyke which crosses the river with a strike of 15° N. of E.—15° S. of W. and maintains that direction steadily as far as the Rer, being seen in all the intervening streams, but not in the intervening alluvium-covered high ground.

Khekra section.—In the Khekra river from its junction with the Goinghata to the point north of west of Lapatra, where it is intersected by the boundary of the gneiss there are exposed a few sandstones, the trap dyke, and about a foot of coaly shale.

Chandnai river.—This river and its tributary, the Chulhot, have not been plotted in detail on the map. Instead of the peculiar winding courses which they follow, they are represented as consisting of long rectangular reaches and bends. It is consequently difficult to represent faithfully the position of the coal seams.

Between the mouth of the Chandnai and the village of Kutkona, there is a much broken section of sandstones in which three outcrops of coal seams occur. In the first, 1′ 6″ of coal is exposed; some of the blocks derived from it consist of very good coal. Neither of the others are of very promising character, but the one near the mouth of the Gumgara is evidently of some size and may contain good coal, though it is not now exposed.

Trap occurs in the bed of the river about one-third of a mile from Kutkona. Just below the village the large trap dyke mentioned above crosses the stream disturbing in its passage, but not to a detrimental extent, the finest coal seam which occurs in this area.

Where most clearly seen, this seam (the base being hidden) consists of about equal parts of good, fair and burnable shaly coal, in all a thickness of 5′ 6″ capped by a massive bed of about 30′ of sandstone.

Whether the position of the dyke is coincident with a fault which has flung the coal on the south, I could not ascertain, but even if it has, the seam in all probability extends throughout a considerable area on the north and west.

The branches of the river which meet close to this traverse a broken section of sandstones for about 2½ miles, after which the gneiss rocks come in. In the eastern branch, near the village of Sirkotonga, the boundary is seen very clearly and is clearly faulted. In the western the boundary is completely obscured by alluvium.

The Rer or Arand section.—In the Rer river west of Jamgula there are some sandstones, apparently of Talchir age. From this northwards many of the reaches expose no rocks whatever; but those which are seen are Barakar sandstones and grits; they are for the most part horizontal. The above-mentioned trap dyke is again seen in the bed of the river to the south-west of Bagdari.

Should coal ever be required in this neighbourhood, I think there is a good prospect of its being found of fair quantity and quality at no great depth and in approximately horizontal beds.

Borings made within a mile radius of Ambera and Kutkona would probably give a fair test of the capabilities of the area.

Rampur Coal-field.

The area for which the above name is proposed is bounded on the north by the Lakhanpur gneiss, on the east by the Mainpat, on the south it passes into the Mand area described below, on the west it is connected with the great area of coal-measure rocks which stretches to Korba.

I do not attempt to make any estimate of area, as my observations were simply confined to the vicinity of the route-track from Lakhanpur to Matringa.

Passing west and south from the Lakhanpur granitic gneisses, which run under the sandstones and trap of the Mainpat, the valley of the Rer or Arand is reached. At Patrapali, west of Lakhanpur, and following it up to its source, the river at first alternately traverses Talchir and Barakar rocks; but in the highest reaches the upper sandstones are exposed.

TALCHIRS.—In the Arand between Chainpur and Jajgi there is a broken section of Talchirs consisting chiefly of sandstones; shales and the boulder bed are, however, not absent. Above (*i.e.*, to the south of) Jajgi for about 2 miles, no rocks are seen, but beyond Ubka, there are some Barakar sandstones, and an indistinct outcrop of Talchirs (?) appears at the road crossing to Lachmanganj. This apparently rests on some quartzite gneiss which strikes into the bed of the river a little further on.

For 5 miles beyond this the river shows no signs of any Talchirs, but it is of course possible that some may exist as there are many long sand-covered reaches.

South-west of Lipingi there are Talchirs, and they crop out at widely separated intervals for about 3 miles.

The boundary of the Talchirs strikes the river again a little above its junction with the Sagar stream, and crosses it a little beyond the high road ghât. The

Talchir rocks occur from this point for about a mile eastwards, after which they are covered by some sandstones which may be either Barakars or upper sandstones. This point remains still to be determined.

Beyond the village of Kesma again Talchirs (or rocks lithologically so like them as to be undistinguishable) re-appear. Fragments of coal or coaly shale occur sparingly in the bed of the river, but there is no trace of Barakar rocks in the main stream and the trap-capped hills on either side of the valley appear to be altogether comprised of the upper sandstones, so that I am inclined to believe that the coal, &c., must be derived from layers in the latter.

BARAKARS.—The first or most northern outcrop of Barakars is exposed in the reach of the Arand south of Ubka, where there are sandstones resting on coaly shale. Several other outcrops occur in the river up to the road crossing.

In the country west from this there are several peculiarly shaped hills, notably one called Ramgarh. The summit of this hill is 3,206 feet above the sea. The upper portion consists of a massive rectangular block of the upper sandstones, which are here from 550 to 600 feet thick; these rest on a pedestal of Barakar rocks, the highest bed of which is a coal seam containing about 4′ 6″ of rather stony coal. The summit of the hill is capped by trap. Owing to the antiquities, cave temples, &c., several notices of it have been published, and the existence of the coal seam has been referred to by Colonels Ouseley[1] and Dalton.[2] A description of the hill has also been published by the present writer.[3]

Returning to the Arand section. In the vicinity of Tunga, there are some slabs of coaly shale which appear to have been derived from no very distant source. As no seam appears in the Arand close by, it is probable that one is exposed in some of the tributary streams, possibly the Gerua, as some fragments of coal shales were found in it. I had heard previously from the Lakhanpur Raja that coal did occur somewhere in the neighbourhood of Tunga, but I had not time to hunt up all the surrounding country.

These Barakars continue up to a point north-west of Lipingi, but there is no trace of coal. Westwards from this, the same rocks were traced to Lachmanganj, their existence under the alluvium there being proved by the debris from a well in the compound of the Raja's shooting lodge.

Barakars are next met with in the Arand, south-east of Kumrewa. They consist chiefly of massive felspathic sandstones and grits often much iron-stained.

In a reach to the east-south-east of Sair, there is a seam consisting of coaly and carbonaceous shale, apparently not containing any good coal. This is the locality marked '*coal-field*' on the old maps.

It is probably the source of the coaly fragments seen in the bed many miles northwards, but cannot possibly be that of the large slabs seen near Tunga. Shaly fragments of coal may, I believe, be carried in rivers for enormous distances; even in the present sluggish state of the river, fragments may often be seen incessantly rolling over and over along the bottom.

[1] J. A. S. B., Vol. XVII, p. 66.

[2] *Op. cit.*, Vol. XXXIV, pt. II, No. 1, p. 24.

[3] Indian Antiquary, 1873, p. 243.

Sandstones, as before mentioned, continue up to the Sair and Kesma ghât; west of the river they extend into the peculiar raviny country beyond Sair.

There the rivers have cut down to a considerable depth; in the massive sandstones producing a perfect maze, very difficult to traverse.

A locality for coal on the Chornai river is marked on the map, but this I did not visit.

I have above alluded to the doubtful character of the sandstones at Kesma.

UPPER SANDSTONES.—West of the Arand valley there are a number of flat-topped and sharply scarped hills, which are evidently formed of sandstones identical with those of the Pilka hills. On the east, too, similar scarped faces show under the trap of the Mainpat. The first locality at which these rocks were actually examined was in the hill east of Kesma. They are coarse grits, presenting no striking contrast in lithological characters to some Barakar rocks. About 3 miles north of Matringa the Talchirs are covered by sandstones, which seem to belong rather to this group than to the Barakars. But they still require much close examination.

In the streams which constitute the head of the Arand, there are fallen masses of trap and laterite which have been brought down from the tops of the hills.

The Matringa ghât is an almost sheer descent of 900 feet into Udepur. At the top of the ghât there is laterite *in situ*, and below it a succession of argillaceous shales, and pink, white, and yellow sandstones, which become somewhat pebbly towards the base. If 600 feet is added for the thickness of the sandstones in the hills above the ghât, then we should have a minimum total of 1,500 feet for the thickness of this group.

Between the foot of the ghât and Amuldih there are some trap dykes, which are probably continuations of some observed in the Kairja valley, near Bakulo, by Mr. W. T. Blanford.

The evidence afforded here of disturbance of the coal-bearing rocks is very strong, there being a difference of level between the Barakars and Talchirs of Sair, &c., and those of Udepur, in the Mand section, of at least 1,000 feet.

That they occupied these relative positions at the time of deposition is most difficult to believe; it seems much more probable that they were once connected, and that the difference of level was produced subsequently, possibly at the period of the outpouring of the Mainpat trap. The discovery of coal measures on the Hazaribagh plateau has already pointed to the probability of the present level of the plateaus as contrasted with that of the surrounding valleys, being at least to some extent due to local upheavals.

The Mand Coal-field.

The connection of the Udepur coal-measure (Barakar) rocks westwards with the great spread which includes the Korba field, has been pointed out by Mr. W. T. Blanford. My observations were confined to the Udepur area, *i.e.*, to the valley of the river Mand, and the areas to the north and east of it.

This is a very irregular shaped area, extending from north to south, for a distance of 35 miles. On the north it is connected by upper (Hingir) sandstones with the Rampur field. On the south and south-east it is bounded by Vindhyan and metamorphic rocks which strike steadily in the direction of Korba. On the east the coal measure rocks are covered by the upper sandstones, and it is uncertain whether the former appear in the valleys beyond the ranges formed of these sandstones. On the north-east, besides the overlapping sandstones, a portion of the boundary is formed of granitic gneiss rocks.

TALCHIRS.—So far as is known at present, the areas of Talchir rocks occurring in this field are of small size. Proceeding from north to south, the first Talchirs encountered with occur detached from the field, in the valley of the Kairja river, north of Rabkob.

In the section north from Mirigurha, granitic gneisses with, for the most part, an E. W. strike, occupy the bed of the river nearly up to the Kumhar road-crossing where Talchirs come in. These, especially the boulder bed, continue up to half way between Bajpar and Bakulo, where there are some hills of yellowish or grey sandstone which seemed to be of Talchir age.

At Rabkob several of the reaches of the Mand river are occupied by Talchirs, blue and grey sandstones and the boulder bed.

North-west of Rabkob, in the valley of the Samasota (or Gopal) river, there is an area of Barakar rocks, showing evidence of extreme disturbance. On the borders of this there are some outcrops of Talchirs, and in the centre of it, at the broken crest of a very remarkable anticlinal, rocks of the same group are exposed.

From this to the south-east corner of the field no Talchirs were seen in the Mand or any of its tributaries. At the south-east corner, Talchirs, resting on granitic gneiss, crop from underneath the Barakars; they are last seen in the Sukia stream, and consist chiefly of shales and sandstones with imperfectly developed boulder bed.

BARAKARS (COAL MEASURES): *Mand River section.*—Passing westwards down the river, from the Talchirs seen near Rabkob, the first Barakars met with occur in the reach east of Saipur. At the north end of it there is a small coal seam, of which the section is as follows:—

Dip 5°, to W. N. W.

Coaly shale, about	8″
Parting...	8″
Coaly shale and coal	1′ 4″
Base hidden.	

Beyond this, there are massive beds of sandstones and grits in some of the reaches; in others, for from 1 to 2 miles, no rocks whatever are exposed. Between this and Khargaon there are two or three outcrops of coal and coaly shale, but no coal. At Khargaon there are two seams, the upper containing carbonaceous shale, and the lower, which is seen under a massive sandstone, contains 1′4″ shaly coal. Half a mile from the mouth of the Saria stream there are several seams containing carbonaceous shale with coaly layers. From this, for 3 miles, there are only a few outcrops of sandstones, several of the reaches being filled with sand. A short distance from the Kopa river there is a seam containing a foot of coaly shale, base not seen. Between the mouths of the Kupa and Khanddhoa there are two seams of grey and carbonaceous shales with a dip of about 10°, to S.

A similar outcrop is seen in the reach west of Hathi. After this, up to a point 1 mile south of Dorki there are only a few outcrops of a peculiar yellowish and grey sandstone, not Talchir, but very unlike typical Barakar.

Under the east bank close by there is a seam of coal shale and poor coal, the latter 15 inches thick. The base of the seam is not exposed. Dip, 5° north-east. After this, there are numerous sandy reaches showing only rare exposures of sandstone.

Below Koraikela, hills consisting of the upper sandstones abut on the river.

From this to the boundary formed by Vindhyans at Daijari, the only rocks seen are sandstones occasionally associated with shales, which latter are in two cases somewhat carbonaceous.

The Vindhyan and gneiss boundary runs with the last reach, and in one place gneiss is exposed in the bed of the river. This boundary did not seem to be faulted. The high ridge of quartzites probably formed the boundary of the Barakars at the time of deposition exactly as it does now.

Tributaries of the Mand.—Above Rabkob fragments of coal were found in the bed of the Mand, which were apparently brought in by some of the small southern tributaries.

Kairja river.—In the Kairja, Barakar rocks extend for about three-fourths of a mile from the mouth. Near the base there is a seam consisting of carbonaceous and coaly shale with thin layers of coal. The boundary appears to be natural: a boulder bed, possibly of Talchir age, rests on gneiss; but there is also some evidence of crushing up and disturbance at the junction.

Samasota river.—At the mouth of the Samasota (or Gopal) stream, north-west of Rabkob, there were abundant fragments of coal, which proved that there was an extension of the Barakars in that direction. The section in fact abounds with coal seams, which at first have a slight rolling dip, but evidence of disturbance soon becomes apparent, and the river gives a section of a fine anticlinal, in which, on the rise, the seams and associated sandstones dip at angles from 40° to 55°, to east. From underneath these, a Talchir boulder bed with associated shales and sandstones crops out, but after one-fourth of a mile or so the Barakars re-appear; but the fall of the anticlinal is less steep than the rise, and the dip is not too great for the working of some of the seams. The following is a list of the seams seen in this river:—

	Ft.	Ft.	In.
1st.—Fair coal under massive sandstone, dip, 8° north-west . .		1	3
2nd.—Shaly coal—seen		3	
3rd.—Shaly coal much weathered	9		
Banked with sand, not exposed	4		
Good bright coal	3		
		16	

Base not seen, dip variable, 5°—8° to West-30°-North and North-West.

4th.—In a North-East to South-West reach, not represented on the map.

	Ft.	In.		
Coal	3	4		
Grey shale	6			
Coal and carbonaceous shale	1	6		
Grey shale	1			
			11	10

Sandstone.

Dip North-East.

5th.—A fine large seam exposed on the southern bank, dip quaquaversal.

	Ft.	In.		
Sandstone			20	
Seam—				
1. Shaly coal, about	2			
2. Coal, inferior, but burnable	1	11		
3. Grey shale		10		
4. Flaky coal shales with irregular coaly layers	9			
5. Coal, good, varies	1	6		
6. Grey shale	2	2		
7. Same as 5	5			
			22	5

Base not seen.

Unless there be coal below, I do not think this seam could be worked with any good result. This seam may be the same as No. 3. I think it is, for No. 4 is repeated in the next reach; the thickness slightly altered, but the relative position of the component layers the same. After it, there is a long south to north reach, towards the end of which, before the entrance to an east to west one and then continued in it, there is the following remarkable section, showing an amount of disturbance unparalleled in those portions of the Sirguja coal-fields which have been as yet examined:—

	Ft.	In.	Ft.	In.
1. Sandstone q. p.			30	
(1) 2. *Seam*, dip 33° East-North-East.—				
a—Coal, good	1			
b—Shale	3			
c—Carbonaceous shale, with coaly layers	3	10		
d—Coal, about	2			
			9	10
(2) 3. Sandstone, about			50	
4. *Seam*—				
Stony and shaly coal			13	8
5. Sandstone			42	
(3) 6. *Seam*, dip 50°.—				
Coal withc arbonaceous shale parting	4	3		
Covered	9	9		
			14	

				Ft.	In.
	7. Sandstone			29	5
(4)	8. *Seam*—				
	Coal and coal shale, much hidden			9	9
	9. Sandstone			44	5
(5)	10. *Seam*—				
	Coal and carbonaceous shale frequent partings, but much of the coal good			34	4
	Dip 50° falling to 45°.				
	11. Sandstone			39	0
(6)	12. *Seam*—				
	Concealed	23			
	Flaky coal	7	7		
				30	7
	13. Sandstone			51	0
(7)	14. *Seam*—				
	Coal and carbonaceous shale portions good			20	7
	15. Sandstone			75	0
(8)	16. *Seam*—				
	Poor earthy coal and carbonaceous shale seen			4	
	17. Sandstone with pebbles, say			50	
	TOTAL			517	7

Talchirs, boulder bed, shales and sandstones, in a north-west reach. Barakars come in again after one-fourth of a mile or so. Close to the boundary there is a seam of coal and, in the next reach one with a dip of 35° to N. W., it is 15 to 16 feet thick, and is of very variable quality. In the next reach, E. W., there is an exact repetition of the section on the other side of the Talchirs, but with the dip in the opposite direction, 35°—40° W. and W.-N.-W. changing to north towards the end of the reach.

In the next long north to south reach there is a seam of 4′ 6″ of coaly shale and coal, dip 15° to N.-E. showing a complete change of direction. I am not sure whether this is a repetition of one of the above seams. Another seam is seen in the next reach after which the sandstones again resume their horizontal position, and the same bed may be traced for a considerable distance.

Strong nests of coal occur in some of these sandstones.

A few reaches further, there is a seam at least 10 feet thick, consisting of the same flaky-looking coal.

A short distance beyond the Boro and Jamungri road ghât there is a 5 feet 10 inches seam of stony and shaly coal; the upper half contains fair coal; the dip is low to south-east, but the bedding all about appears to be very irregular.

Another seam in the next reach is seen on the Boro side. It contains about 10 feet of shaly coal, a portion of which has been on fire, though it contains much impurity; a fresh fracture shows a fair proportion of bright layers. Beyond this, there was still evidence of seams occurring in the higher reaches.

Between Tuludha and the Samasota, *viâ* the Jamungri road, there are several outcrops of Talchirs and gneiss, which afford further evidence of the disturbance and disruption of the beds in this neighbourhood, and render it extremely doubtful what the extension of the seams in a western direction may be. Should it ever be required to search for coal here, I would recommend the vicinity of Boro, east round to south at a distance of about half a mile, as the most favourable for making trial borings. The evidence of extensive disturbance of the seams, and consequent difficulty of working them in the country between the Boro hill and the Mand, would render it less desirable to test that area in the first instance.

Meria Kota stream.—In the Meria Kota stream beyond the first tributary, there is a seam of poor coal, of which 6 feet is exposed, dip to north-east. The same seam is again seen further on, where it shows a thickness of about 8 feet.

Some distance beyond two small waterfalls, there is a seam with a dip of 30° north. It is faulted against a bed of sandstone. Close beyond is a seam (possibly the same) with a dip of 8° north-east. It does not contain any continued thickness of good coal, being much parted by shaly layers. This is followed by another seam of about 6 feet with a dip of 10° to east. The coal is for the most part flaky and inferior. At the east to west boundary, west-south-west of Jamungri I saw no traces of coal from the higher parts of the stream, though it is probable that some of the Boro seams may extend thus far eastward. At the same time, it may be that the Barakars are covered up within a short distance of this by the higher sandstones and grits.

In the stream which rises near Jamungri I commenced to examine south-west of the village. Sandstones and grits, apparently Barakars, continue for more than a mile. Then Talchirs from the eastern boundary occupy the bed of the river for a few reaches, after which it runs in a deep gorge, which it has cut for itself in massive sandstones. As represented on the map, this river has the unusual feature, for one in a rocky country, of having two mouths whereby its waters join the Samasota. The explanation is that the narrow gorge being unable to carry off at times the whole of the water, the surplus finds a passage for itself by a northern outlet. I did not see any seam in this stream, but fragments of coal occur. Rolled fragments of gneiss abound, being brought in by the eastern tributary.

Ududha river.—The river south of Ududha (Hudhuda of the map) traverses deep gorges cut in massive sandstones. South-west of the village there is a seam of which the top only is exposed. At the highest point examined, a little north of west of the village there were still fragments of coal brought from higher reaches.

Saria river.—In the Saria river a little beyond the road-crossing, there are two seams of carbonaceous shale with coaly layers.

For several miles sandstones only are seen; they show more tendency to roll than is common in other parts of the area; the prevailing dips are 5°—10° to west and south-west.

North of the village of Konda there is a seam containing a few inches of coal in the exposed part. In an east and west reach higher up the stream there is a seam which, in addition to carbonaceous shale, contains about 3′ 6″ of flaky coal.

A short distance beyond this, there is another badly seen seam containing, apparently, several feet of coal mixed with shale.

At the Baisi and Ambgaon ghât and for some distance up and down stream a nearly horizontal seam paves the bed of the stream; it contains some good coal, but the whole thickness of the seam does not apparently exceed 5 feet. Between this and the Doridih and Ambgaon ghât there are no outcrops visible; but fragments of coal occur brought down from above. South of Potia there are sandstones which are probably Barakars.

Simi river.—About ½ a mile from the junction there are two seams of coaly shale with much carbonaceous shale, neither of any use. A little further on there is a seam with a dip at first to the west, afterwards changing to 12° south. It contains about 15′ of grey and black shales, and, in one place, a band of rather less than a foot of fair coal. The same seam shows at intervals for a considerable distance. I did not examine beyond the Chithra and Simipali ghât.

Kopa river.—From the mouth up to Chithra the rocks are for the most part covered. Near the mouth of a small stream, which joins the Kopa south-west of Chithra, there are three seams of from 2′—3′ each; they contain coal of fair quality mixed with carbonaceous shale. The dip of the first is 17° to west, but the third rests on a sandstone which is locally tilted to 35° to west.

A short distance beyond the southern tributary, there is a seam of rather more than 3 feet of carbonaceous and grey shales, with some coaly layers towards the base. In the reach entered by the next northern tributary, there is a considerable seam of carbonaceous shales, but no coal. Beyond the Kodardih stream there is a seam of carbonaceous shale 3′ 8″, dipping at 5° to south-south-west, but no coal.

Beyond this up to the Bartapali crossing I saw no seams, the river for the greater portion of the way being in a deep gorge of massive horizontal sandstones.

The last seam but one, mentioned above, is apparently one alluded to by Mr. W. T. Blanford;[1] it rolls a good deal and is of uncertain dip, but I saw no sign of coal in it

Khanddhoa river.—North of Hathi is a seam close to the road; it consists of 18′ of slightly coaly shale with a dip to south of about 8°.

About 2½ miles beyond this there is a seam with about 10″ of coal towards the base, the upper part consisting of grey carbonaceous shales, dip 5° to west. In the interval between these there are massive sandstones and two or three outcrops of carbonaceous shale, but no coal.

Beyond this there are several repetitions of the same seam and several outcrops of carbonaceous shales. At the road crossing between Nouapara and Jogra there is a seam containing less than a foot of inferior coal with a slight rolling dip to south.

Kurja river.—In the stream north of Pori there is a seam containing 1 foot of inferior coal much mixed with shale, dip 3° east. Before it was reached a number of transported slabs of coal with shale, generally 12″ thick, were found lying in the stream. I can scarcely believe that they were derived from this seam, as they appear to be of much better material than what is seen *in situ*, but I did not see any traces of coal of similar character in two reaches further west, which were the limit of my examination in that direction.

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[1] Records, Vol. III, pt. 3, p. 71.

Baghoud river.—From the mouth to the village of Galimar the Baghoud only shows sandstones and shales; some flakes of carbonaceous shale occur, but none *in situ*. The upper part of this river as also of most of the foregoing one traverses the upper or Hingir sandstones.

Bendo river.—In this river there are several outcrops of carbonaceous shale but no coal.

Jhampi river.—In this river the rocks exposed by the section are red, yellow, and white sandstones; no trace of coal or carbonaceous shale. I am inclined to believe that all these belong to the upper group.

Kurket river.—For half a mile from the mouth no rocks are seen; afterwards, towards the top of the first reach, there are coarse sandstones and grits similar to those in the Mand. Beyond this the river exposes Talchirs. The masses of coal seen in the bed are derived from seams in the Raigarh and Hengir field, which are traversed by the higher reaches of the river.

In reference to the economic prospects of this valley, I am distinctly inclined to regard them favourably. While it must be admitted that the majority of the seams which have been examined, as they happened to be exposed, do not disclose coal useful in quantity and quality, it should be remembered that the sections are much covered and the disturbance of the beds (excepting in the few noted instances) has not proved sufficient to give anywhere a complete section of the succession actually existing.

In some cases it is possible to trace the same bed of horizontal sandstone for several miles. The area being in the centre of the basin there is a good prospect of boring proving the existence of valuable seams.

Upper or Hingir Sandstones.

On the northern and for a considerable portion of the eastern boundary, the Barakar rocks are covered up by the upper sandstones. The peculiarities of the Matringa ghât section, alluded to below, afford evidence of great disturbance of level between different portions of the coal-fields. But I must confess myself not prepared at present, with the imperfect data which I possess, to attempt an explanation of the action which has taken place. The difference between the level of the Talchirs of the Arand and of the Samasota, whether produced by flexion, faulting or aboriginal deposition, amounts to from 900—1,000 feet. In all probability, this is really a measure of the subsidence which has taken place.

North-east of Porea there are sandstones with pebbles. These appear to be more common at and near the base of the hills than high up in the sections. The Boro hill and its neighbours are composed of ferruginous sandstones and grits. The scarped range to the east of this is formed of similar rocks, but less ferruginous and more compact. They are split up into angular blocks, in such a manner that at a short distance I supposed them to be metamorphics.

The spur south of Balpeda is composed of sandstones and grits: [illegible] near Jamungri there are [illegible] sandstones and white argillaceous rocks which may be Barakars; but I rather incline to the [illegible] included with the upper rocks. The range east of Jamungri is formed of sandstones and grits, south and east of which metamorphic rocks come in and bound the field up to the Sisringa[1] plateau. It is possible that there are sandstones on this plateau; but the first place in which I again met with them was in the Ghoradah hill; from thence the boundary, from various reasons, is very indistinct, but I believe it approximates closely to what is represented on the map, *i.e.*, it runs round the Enderkona hill.

The hill Ghoradah, 2,595 feet or some 1,500 feet from its base, is formed of sandstones and grits capped by laterite. All the hills south from this appear to be of the same sandstone, so that the gneiss boundary must be thrown considerably east of its position near Rabkob.

Whether gneiss or Barakars occupy the valleys, which occur further east of this range of hills, remains to be seen. It is probable that all the hills and ranges marked with distinct scarps are formed of the upper sandstones.

The Enderkona hill is formed principally of a pinkish sandstone, which is scarped similar to those in the hills further north. At Kida the base of the hill is formed of compact purple sandstone. Round the base of Enderkona hill the boundary runs to Aghori, and from thence to the hills below Gumar, which touch the Mand, and are continued again on the western bank.

The river south of Taraikela exposes red and yellow sandstones with occasionally white grits; some of the former contain red jasper pebbles.

The high ground south of Taraikela is formed of ferruginous sandstones, grits and shales, with bands of iron-stone. From thence to Kataipali the boundary of these upper rocks has been roughly traced in that neighbourhood; they lap over on to the Talchirs. Their further eastern extension from this was not traced.

Sufficient has been said above to show how complete the unconformity of these rocks is with respect to the older formations, and yet the difficulty of separating them from the underlying Barakars in some sections is excessive. Taken as a whole, their lithological characters and the absence of coal are such as to justify their abstraction from any close connection; but individual beds often present the very strongest resemblance to certain grits and sandstones of the Barakars. In all these particulars, as well as in their physical characters, they present much similarity to the grits of the Rajmahal hills.

I have often been struck with sections especially round the Mainpât and neighbouring *pâts* as being exact repetitions of some I examined in the Rajmahal hills. Here as there, there are massive distinctly scarped sandstones, which rest indifferently on Talchirs, Barakars or gneiss, and are covered by trap and massive laterite.

Since the above was first written, these upper (Hingir) sandstones have in part been identified by their fossil contents with the Kamthi group, but representatives of higher Gondwana groups are also very possibly present too.

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[1] A village close to east-by-north of Chuimati summit.

Vindhyans.

It has been mentioned above that the coal-bearing rocks are cut off on the south by a ridge of rocks of Vindhyan age. These consist of quartzites and quartzitic sandstones.

At intervals granitic gneisses intervene along the boundary.

The quartzites are first met with on the west bank of the Mand, opposite Ero; there they form a succession of high ranges, often with steeply scarped sides. The strike of these hills corresponds with that of the boundary, and indeed of the river itself, for 2 miles. Below Daijari the boundary is suddenly deflected to the east, which direction it maintains for several miles, and then it strikes in the direction of Sambalpur.

The observations hitherto made on the metamorphic rocks are too scattered and detached for special record. It will be an interesting task to trace the origin of the gold which is found in the old alluvial deposits of the tract which extends between the Mand and Ebe rivers. As these deposits lap round a central group of metamorphic rocks, the existence of auriferous quartz reefs in them may very possibly be hereafter proved.

Report on the Pench River coalfield *in Chhindwára District, Central Provinces, by* W. T. BLANFORD, F.R.S., *Senior Deputy Superintendent, Geological Survey of India.*[1] (*With a map.*)

The coal seams described in the following pages occur at a distance of from 12 to 20 miles north-north-west and north-west of the station of Chhindwára, in the Central Provinces, and in the neighbourhood of the river Pench, a tributary of the Kanhán river and ultimately of the Godávari. The occurrence of coal at one of the localities, Barkoi, has been known for some years. It was first discovered about 1852, and was mentioned by the late Mr. Hislop in a paper published, in 1855, in the Quarterly Journal of the Geological Society of London The country was roughly mapped, both geologically and topographically, by Mr. J. G. Medlicott, of the Geological Survey of India, in 1856, and the tract in which coal seams have now been discovered is shown, in the map,[2] to be formed of the rocks of the Indian coal measures, or Damuda series of the Survey classification. Mr. Medlicott's survey was necessarily merely general, and could not comprise the search for outcrops of coal, a task involving the examination of every stream and nala, of every hill side and every field. The utmost that could be done was to define the area in which such a search could be carried on with a chance of success.

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[1] The trial borings in the Shahpur coalfield having proved very unpromising, the prospect of a coal supply in this region turns to the Pench river field, some 35 miles to the east on the same (southern) border of the Sátpura basin of Gondwána rocks. As a good indication of what is to be expected there, Mr. Blanford's report (written 16 years ago) is published in anticipation of the detailed survey to be shortly undertaken. The line of localities marked on the annexed map sufficiently indicates the position of the coal measures.

[2] Memoirs of the Geological Survey of India, Vol. II, part 2.

In the present instance there seems to have been unusual unwillingness or apathy on the part of the natives of the district, who alone could effectually search for outcrops of coal seams, in furnishing information of their existence. Officer after officer has been compelled to report his inability to ascertain the existence of any other coal in the district than the Barkoi seam, and it was ultimately by accident that Major Ashburner, the present[1] Deputy Commissioner of Chhindwára, became acquainted with the occurrence of the mineral at Sirgori, and following up the discovery most energetically, succeeded, in the short space of three months, in ascertaining its presence in the several places mentioned below.

I am happy to report that I have been able to form a highly favourable opinion of the coal and of the facilities for working it which are presented by its mode of occurrence.

Before proceeding to describe the several outcrops in detail, it may be useful to mention briefly the peculiar topographical and geological characteristics of the tract in which they occur. Upon the former depends the facility or difficulty of communication with adjoining districts, and upon the latter the existence and area of the coal field.

Physical geography of Chhindwára District.

To the north of the Chhindwára district lies the flat open valley of the Narbada, to the south are the broad plains of Nágpur, watered by the tributaries of the Godávari; these areas are approximately at the same level, about 1,000 feet above the sea. They are separated by a tract of much higher country averaging at least 2,500 feet and being part of a belt which may be considered to stretch nearly across India dividing, in the west, the watershed of the Narbada from that of the Tapti; in Central India, intervening between the Narbada and the feeders of the Godávari; and to the east, separating the valleys of the Son and other affluents of the Ganges, from the tributaries of the Mahánadi and other rivers of Orissa. In the country between the Narbada and the Wainganga, this belt is about 80 miles broad, the northern portion consisting of massive flat-topped hills, intersected by deep ravines, all covered by dense jungle traversed by very few roads, and very thinly populated. The southern portion, which is the true dividing ridge, is far less irregular, and in most parts consists of a broad undulating table-land, generally fertile, and, in many places, well populated and cultivated. Upon this southern portion are the Civil Stations of Betúl and Chhindwára.

Distribution of coal-bearing rocks.

Although a very considerable proportion of this belt of country in the Betúl, Chhindwára, and Narsinghpur Districts consists of coal measure rocks (Damuda), these are chiefly found in the deep valleys and on the sides of the hills of the wilder northern portion. Such is the case at Mopáni, on the Sitariva, near Narsinghpur, and in the several known coal localities of the Táwa valley. So far as the country has been hitherto mapped, the only coal measure rocks known to occur upon the table-land forming the southern portion of the belt are those in the neighbourhood of the Pench river, in which the seams now discovered occur. This circumstance is of great importance, because communication with the country, either north or south, involves only the descent of one scarp, while from all the other known coal-fields of the neighbourhood of the Narbada, communication with the south involves an ascent of from 1,000 to 1,500 feet, in addition to the descent of the southern scarp. The distance of the various coal localities from Chhindwára is from 12 to 20 miles; from Chhindwára to the foot of the ghât at Rámakona is 28 miles, and from Rámakona to Nágpur 50, total 90 to 98 miles.

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[1] That is, in 1866.

General geological structure of Pench river coal-field and neighbourhood.

The general geological features of the neighbourhood of the Pench river coal-field may be mostly gathered from Mr. Medlicott's map. The following brief description is derived chiefly from the map, partly from my own observations. The country north of the station of Chhindwára consists of metamorphic rocks, which extend to the west far beyond the town of Umrait, and continue for about 10 miles due north of Chhindwára, when the sandstones and shales of the Damuda series are brought in by a fault of unknown dimensions, but undoubtedly of considerable magnitude; probably, north of Chhindwára, of some thousands of feet. Upon both formations indifferently is a great spread of horizontally or nearly horizontally bedded trap, which covers the whole country further east, but, to the west, has generally been cut through by river valleys, and denuded, so as to expose the subjacent formations; caps and patches of the trap remaining here and there. To the north of Umrait, between that town and the villages of Barkoi, Butaria, &c., a patch of trap covers a considerable tract, concealing the boundary between the metamorphic rocks and the Damudas, and trap again overlaps the boundary north-east of Chhindwára. From a few miles north of the Pench again all is trap. The country in that direction rises into a great table-land, in parts as much as 3,500 feet high.

The base of the trap is extremely irregular: the beds have been poured out upon an irregularly denuded and uneven surface of metamorphic and sedimentary rocks, and masses of the igneous rocks, filling up previously existing hollows in the older formations, occur even at the lowest portions of the country now exposed. Thus trap occurs in the bed of the Pench river in two places, one north, the other south of the villages of Chenda and Digawáni. Trap dykes intersect the sedimentary and metamorphic rocks in places, but they do not appear to be very numerous, nor to affect the quality of the coal.

Besides the Damuda or coal measure sandstones and shales, I found a considerable portion of the Pench valley to be occupied by rocks of a very different mineralogical character, thick beds of deep red clay with interstratifications of coarse sand and sandstone, and bands of nodular limestone. These do not appear to contain coal, and their appearance strongly recalls that of some beds, which I described in 1860 as the Panchet series,[1] and which overlie the coal-bearing rocks of the Raniganj field. But my time was too limited to allow me to investigate this intricate question, and my attention was necessarily chiefly confined to the coal beds.

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[1] It should not be forgotten that this paper was written 16 years ago before Mr. H. B. Medlicott had classified the Gondwána beds of the Sátpura region and before anything definite was known of the Godávari Gondwánas. The only areas of these rocks that had been properly surveyed were those of the Damuda valley. The supposed Panchets doubtless belong to a much lower horizon and are in all probability Motur.

Villages referred to, marked on map.

On the accompanying map (an extract from sheet No. 4 of the Revenue Survey of the Chhindwára District) will be found the various villages referred to below as in the neighbourhood of the coal outcrops. The majority of them are also marked upon the map, already referred to, as published to accompany Mr. Medlicott's report on the central portion of the Narbada district. These villages extend in a line running nearly due east and west for a distance of about 16 miles.

In describing the localities in detail, I shall commence with those farthest to the east, and proceed regularly westwards.

I. Sirgori seam.—The most eastwardly locality in which coal has as yet been discovered is close to the village of Sirgori, and nearly a mile north of the Pench river. The coal was found in a well sunk, twelve years ago, by the malguzar or patel of the village; and this circumstance coming accidentally to the knowledge of Major Ashburner, led to the discovery not only of this seam, but of all the others between Sirgori and Barkoi. Major Ashburner sank a shaft by the side of the well, and at the depth of 28 feet came upon the coal. All the beds cut through were of sandstone, coarse or fine; and the roof of the coal consists of coarse sandstone, obliquely laminated. After cutting into the coal more than 3 feet, water came in rather rapidly, and the shaft was stopped. With some little difficulty from the influx of water, I succeeded in digging into the coal further, until I had reached 4 feet 9 inches from the top of the seam. How much thicker it may be, I cannot say. The whole is of good quality, perfectly uniform, without shale partings.

Thickness of seam.

Quality of the coal.

The coal burns excellently, and leaves a considerable quantity of perfectly white ash. The most remarkable point about this coal is its freedom from iron pyrites. I have never seen any Indian coal which appeared so little impregnated. This is a most valuable property—the absence of pyrites tends to ensure the coal from decomposition on exposure to the weather, and from liability to spontaneous combustion; and if sulphur be not present in some other form, it especially qualifies the coal for the manufacture of iron and for forge purposes.

Geological character of neighbourhood and probable extent of seam.

The well in which the coal was found is just south of the larger of the two collections of houses composing the village of Sirgori. These two portions of the village are about a quarter of a mile apart, the larger being north-east of the other. In a nala between them fine sandstones are exposed, dipping north about 5°; these may be traced beneath the north-east portion of the village, and re-appear on the low hills about 200 yards east of the well; dipping at that spot north-north-west, at the same angle as before. The beds thus appear to be continuous along their outcrop for a distance of nearly half a mile, and unless some break of the rocks occur in the ground between their outcrop and the well, (of which I could trace no indication,) the coal should be continuous beneath them throughout that distance at least; how much further it is difficult to say. This is along the strike of the beds east and west. Coming up the dip of the beds towards the south, sandstones and shaly beds are seen with the same north dip in two or three places, the ground being however covered thickly with surface soil, so that very little can be seen. No trace of any outcrop can be found, and in a well 22 feet deep, just south-east of the smaller or south-west portion of the village, no coal was found, nor yet in another well, about 200 yards further west. Yet, if the coal continued at the same dip, its outcrop should be either at these wells or a little south of them, and in either case some indication of the coal should be seen in them. Its absence induces me to believe that the coal is, in all probability, cut off by a fault; and there is an indication of such a fault in a small nulla, 200 or 250 yards south-east of the shaft in which the coal is seen. This fault brings coarse grits against shaly sandstone, and it appears to have an east and west direction (perhaps east-north-east to west-south-west, a common direction of the faults in this country). The amount and the direction of its throw are quite uncertain, scarcely any rocks, except the overlying trap, being seen in the neighbourhood to the south. Boring is very desirable about this to test the extent of the coal, which, if the fault be a downthrow to the south of no great amount, would be found on the south side of the fault within a depth not too great to prevent its being worked. If the fault be an upthrow to the south, the coal will of course be cut out in that direction.

A small stream runs in a valley north of Sirgori village (the larger portion), and then passes east of the village, and runs southward, passing a little east of the shaft. In this stream, east of the village, and about 200 yards north-north-east of the shaft, sandstone is seen overlying shale,—the latter very carbonaceous in parts, dipping about 3° to north-north-west, and containing fossil plants. The sandstone differs greatly from the much coarser beds immediately overlying the coal. It is necessary to mention this, as the dark shales may be easily mistaken for an outcrop of coal, and it might be thought that the seam is here brought to the surface and repeated by a fault. I can see no indication of such an occurrence, but every reason, on the contrary, for believing that the coal underlies all these rocks.

Going further north, the beds appear to dip regularly until about 200 yards north of the village, and a quarter of a mile from the shaft where there may possibly be a fault. It is not very clearly seen, nor can even a guess be hazarded as to its amount or the direction of its throw; indeed, it is not certain that anything more than a sharp bend in the rocks exists, and of course it is quite possible, and even probable, that the coal recurs beyond.

Necessity for boring, and spots where it is desirable.

It will thus be seen that for at least half a mile along the strike, and for nearly as great a distance along the dip, there is every probability that this seam is continuous; and it is in the highest degree probable that the coal will be traced far beyond these limits if proper boring operations are carried out. Before attempting to work the coal, a few preliminary borings should be made, especially in the direction of the dip, that is, north and south of the well in which coal has been found. These borings are needed both to ascertain, more definitely than can be done by surface exploration, the extent of the coal seam, and also to prove whether its thickness be constant,—seams of which the roof consists of coarse sandstone, as in the present case, being sometimes variable in thickness. I would point out as one place for a boring the spot immediately south of the large banyan tree, which is itself south of the north-east portion of the village, in order to ascertain if the coal approaches the surface there. Another boring should be made 150 or 200 yards north of the well in the low ground east of the village.

It is also extremely desirable that the coal should be at once sunk through in the shaft, and its thickness ascertained. This might be done at small expense.

Summary of prospects of the locality for coal-mining.

It has, I think, been clearly ascertained that the coal at this place is sufficiently thick to be profitably worked, that its quality is good—in some respects exceptionally so—that the dip is low and highly favourable, and that there is every probability that the seam is continuous over a sufficiently large tract of ground to repay considerable outlay in starting a colliery.

II. Sirgori seam No. 2.—Up the little stream, already mentioned as running north of the village of Sirgori, beyond the spot where indications of a fault are seen, nothing except coarse sandstone is met with, the dip of which is doubtful. About half a mile west-north-west of the village, the outcrop of a second seam of coal is seen in the nala, dipping north. On the north bank of the nala, Major Ashburner sank a shaft to a depth of 18 feet, passing through the seam, which was 3 feet in thickness. The shaft passed entirely through shale and shaly sandstone. The coal was mostly extracted in large slabs, and these, after being exposed on the surface for three months in the dry season, have split up into papery layers, to so great an extent as to prove that the coal is ill suited for carriage to any distance, and very liable to decompose. It is also rather shaly and impure; and, considering that the thickness of the seam is only 3 feet, I do not think it could be profitably mined. The coal burns well, leaving a grey ash, and appears tolerably free from pyrites.

There is not, so far as I can see, the smallest reason for supposing this seam to be a repetition of that seen to the south; the beds do not roll up again, and the two coals differ essentially in thickness, mineral character, and in the nature of the overlying rocks.

Some shales seen in the nala, just above this spot, are so ferruginous that they might be used as an iron ore. The ferruginous portion does not, however, appear to be of any great thickness; all that was seen was a band a few inches thick and somewhat variable in the proportion of iron contained.

III. Chenda seam.—The next locality to the westward is in the bed of the Pench river, 4 miles west of Singori, and half way between the villages of Chenda and Digawáni. The river here runs from north to south. So large a quantity of the mineral is here exposed in the bed of the river, that it is rather remarkable that its occurrence should not have been before noticed; and it shows clearly the utter indifference of the natives of the country to the subject, since they must have known that coal was worked at Barkoi, only 10 miles away, and sufficient power of inductive reasoning may be supposed to exist, even in the minds of Gonds, to enable them to see that the two minerals are identical. The spot was shown by a *gwála* to Major Ashburner, after that officer had offered a reward for the discovery of coal elsewhere than at Barkoi or Sirgori.

The spot is just north of the ford in the Pench, on the road between the villages of Chenda and Digawáni. About half a mile to the south, trap comes in, both in the river bed and on its banks: to the south of the trap, near the village of Dala, metamorphic rocks occur. North of the trap, for a considerable distance, no rocks are seen; at the ford the deep red clays and white sands, to which I have already referred, and which I believe to belong to a higher series of beds than those associated with the coal, are seen dipping about 20°, to south 10° west. They are faulted against the Damudas, or coal measure beds close by, and, about 100 yards north of the fault, coal appears on the east or left bank of the river.

Section of seam and thickness of coal.

At this spot, Major Ashburner has made a small cut into the coal to ascertain its thickness; this cut exposes the following section:—

	Ft.	In.	Ft.	In.
Shale, decomposed, about			3	0
Coal ditto	1	0		
Shale	1	3		
Coal, rather shaly in places, but generally of fair quality	7	0		
Shale, in parts very carbonaceous and containing layers of good coal	2	0		
Coal of good quality	4	3		
			15	6

of which 12 feet 3 inches consists of coal.

Immediately to the north, a trap dyke, running east and west, and about 30 yards broad, crosses the seam. This great mass of igneous rock has tilted up the seam slightly to the north, but does not appear to have much affected the coal. The seam re-appears just north of the dyke, dipping north, at first at an angle of about 10°, but, immediately beyond, at a much lower dip, varying from about 3° to 5°. For about 150 yards from the dyke, the outcrop of the coal seam occupies the bed of the river; then massive sandstone comes in, apparently brought up by a small fault, striking nearly east and west, with an upthrow of about 20 feet to the north. The sandstones dip to north-10°-east at about 5°, and, upon them, about 30 yards further the coal seam re-appears; that is to say, coal of great thickness comes in, and it has every appearance of being the same seam. If not, two very thick seams must here occur, one above the other, and separated by only a few feet. The coal seam continues to crop out in the bed of the river for a short distance, when it is covered by the overlying trap, which forms both the bed of the stream and the hills on its banks. This trap continues for a considerable distance up the river.

The accompanying sketch section will serve to show the manner in which this coal seam is exposed in the Pench.

On the east bank of the river is a rich alluvial and highly cultivated plain, in which no rocks are seen, until hills of trap rise close to the village of Chenda, half a mile away. To the west, the coal is seen in a small nala, about 150 yards from the bank of the river. The spot I believe to be north of the small fault mentioned, as repeating the seam in the river. I could not trace the seam further west, nearly all the rocks being concealed by surface deposits.

Quality of coal.

The quality of the coal is fair throughout; the lower 4 feet 3 inches seam, especially, being of very good coal, brighter and purer even than that of Sirgori, but containing much more pyrites. It burns with rather less flame than the Sirgori coal, and leaves a grey ash, reddish in parts. The smaller quantity of flame is, doubtless due to the Chenda coal being taken from nearer the surface, and partly perhaps to the vicinity of the large trap dyke to the place from which the coal was taken.

Mining prospects of the locality.

Whether this coal can be mined profitably or not, depends upon its continuance to the north under the overlying trap, and this continuance can only be ascertained by mining or boring. Very possibly the trap is of small thickness, and in that case the coal should be found beneath, but the base of the trap is too irregular for any opinion to be formed of its thickness from surface examination.

In any case, however, an enormous quantity of fuel could be quarried from this spot, for quarries could be made along three lines, as far as the outcrop of the coal extends—

1st.—South of the trap dyke.

2nd.—North of the trap dyke, and south of the fault.

3rd.—North of the fault.

No quarries, however, should be made along the third line, especially in the neighbourhood of the river, if deep mining to the north be found practicable. A large proportion of the coal would, of course, be inferior and chiefly suited for local purposes, but the lower portion of the seam would probably be sufficiently good for railway locomotives, and would bear carriage to a distance.

Taking the whole circumstances into consideration, it does not appear to me that this locality is so promising as Sirgori. At the Pench there is probably a thicker seam of coal—indeed the thickest as yet known to exist in Central India; the quality is good, and the dips are highly favourable, but the rocks appear to be much cut up by faults and trap dykes. If the coal is to be mined, it will be beneath very hard trap, entailing some expense in boring and shaft sinking, and the quantity of water met with is likely to be large. But if the coal does continue beneath the trap, its quality will assuredly be far better than in the section now exposed, (provided only that some sandstones or shales intervene between it and the trap, which is probable,) and it will be well worth the expense of a few borings to ascertain this. The spots for boring would be in the bed of the river, 150 or 200 yards north of the place where the coal disappear beneath the trap, and at the base of the hills to the east and west of the same spot.

Locality for borings to prove continuation of coal.

IV. Harrai seam.—At the village of Harrai, 2 miles south-west of Digawáni, coal was found in a well sunk for irrigation. After draining the well of water, however, we found that mud had accumulated to so great an extent in the bottom as to conceal the coal. There would have been considerable delay in clearing this. I cannot, therefore, state the prospects of this seam. The spot is close to the continuation of the large fault already noticed in the Pench, which brings down the red clays and their associated sands and limestones in the same manner at Harrai as further east.

V. Ráwanwára seam.—About a mile north of the last, and half mile south-west of the village of Ráwanwára, the following section is exposed in a nala:—

	Ft.	In.	Ft.	In.
Shaly sandstone			4	0
Fine compact sandstone			2	6
Coal	1	0		
Sandstone, shaly in parts	1	3		
Carbonaceous shale and coal	0	4		
Sandstone, with streaks of coal	0	7		
Carbonaceous shale and coal	0	6		
Dark grey carbonaceous sandstone	0	4		
Carbonaceous shale	0	8		
Coal	2	4		
			7	0
Carbonaceous shale			0	6
Grey shale (bottom not seen)			2	0
TOTAL			16	0

Here there are only 3 feet 4 inches of workable coal, divided into two parts by 3 feet 8 inches of sandstone and carbonaceous shale with threads of coal in places.

The dip at the outcrop is about 7° to the north. To the south there appears to be faulting, and the underlying rocks are not seen. On the west, coarse sandstone dips at 15° to north-10°-east, while to the north-east sandstones, overlying the coal, are seen nearly horizontal.

The coal appears to be of fair quality, but has not been cut into. A small quantity, dug from the outcrop, burned well, almost without flame, and left a grey ash. The seam, however, appears too thin to be worth working, especially in the neighbourhood of other and much thicker beds.

VI. Ráwanwára seam, No. 2.—About a mile west of Ráwanwára, coal again crops out in a nala; the precise thickness is not seen. At one spot there is only 1 foot of coal with shale above and below; dip 10°, to north-20°-west; 30 or 40 yards further west, 3 feet of coal is exposed, divided into two parts by about 2 feet of shale; and a few yards further, 2 feet of coal are seen, all dipping in the same manner as in the first instance mentioned. The two latter may belong to the same seam, the top not being seen in the latter case, and neither top nor bottom in the former. The whole section is very ill seen in a narrow nala, and a small shaft on its north bank would be necessary to prove the thickness of the coal seam, its quality, &c. So far as I could judge, the seam did not appear to be of any great thickness.

VII. Parassia seam.—The next place examined was about three-fourths of a mile west-south-west of the village of Parassia. Outcrops, apparently of the same seam, are seen in three places within a few yards of each other. No clear section is exposed. The coal dips to the north, and appears to be about 5 feet thick, but it is so crushed and decomposed that nothing can be clearly made out. The top of the seam is not seen, and the thickness may exceed that above mentioned; there is much appearance of faulting. On the whole the conditions are not promising, but without a small shaft or boring on the north side of the nala, nothing can be determined with certainty.

VIII. Bhandaria seam.—Rather more than a mile south-west of Parassia, and on the boundary of the village lands of Parassia and Bhandaria, several small seams of coal are seen in the Gogra nala, dipping about 10° to north-10°-west; the dip becoming more westwardly down the nala, which runs towards the east. The section is rather difficult to measure exactly, being somewhat broken. It appeared to be the following:—

	Ft.	In.	Ft.	In.
1. Coarse shaly sandstone			many feet.	
2. Shale, top not seen			2	0
3. *Coal*	1	0		
4. Sandstone of various colours, yellow, red, and black	1	8		
5. *Coal*, very good (the base is concealed by gravel, and the thickness may be a few inches more, but only a few inches).	2	6		
6. Sandstone	3	6		
7. Carbonaceous shale	0	8		
8. Sandstone	0	9		

	Ft.	In.	Ft.	In.
ous shale	0	7		
good	3	3		
11. Shale	0	6		
12. Sandstone	0	3		
13. *Coal*	0	6	15	2
14. Shale	...		0	2
TOTAL			17	4

Or the coal seam, from the top of No. 3 to the bottom of No. 13, measures 15 feet 2 inches, of which 7 feet 3 inches is coal, in general of excellent quality. Just below this a turn in the nala brings in the thickest seam, No. 10, again, and its thickness is correctly seen in a vertical bank: it then consists of—

		Ft.	In.
No. 9	Shale		
10	*Coal*	1	0
	Shale	0	2
	Coal	3	6
	TOTAL	4	8

The difference (1 foot 5 inches) in the two measurements may be due to error in measuring a broken, ill-exposed seam in a nala in the first instance, or to the seam having thickened in the interval, about 30 yards; the latter, I think, the more probable, as seams like this, much interstratified with beds of sandstone, are generally somewhat irregular in thickness, and often excessively so. Indeed the whole section recalls the irregular beds of the western portion of the Raniganj coal-field in several respects.

Thirty or forty yards down the stream, the outcrops of two other small seams are seen, but neither exceeds 18 inches in thickness. They are beneath the above section, 15 to 20 feet of sandstone and shales intervening. Ascending the nala, also, to the east, and 20 to 30 feet above the section measured, a thin, very shaly seam is met with.

Mining prospects of the locality.

Whether this locality is workable or not, depends mainly upon the constancy or otherwise of the seams in thickness, which must be determined by boring or by driving galleries on the seam. The coal appears excellent; the dips, though higher than in some other localities, are not unfavourable; but there is the important drawback, that with the good coal a considerable mass, equal to the coal in bulk, of useless rock intervening between the seams must be dug out, which would much increase the cost of working the coal.

IX. Bhutaria seam.—Close to the boundary between the village lands of Bhutaria and Bhandaria, about a mile west of the former, and barely half a mile east of the latter, is the next locality where coal has been found. The seam dips to the southward or to south-east at about 5°. The outcrop is obscure. I dug out the top of the seam, but under 1 feet 4 inches of splendid coal I found a thick bed of shale, very hard and difficult to cut. After sinking into this for 1 foot 10 inches, I tried another spot, a few yards further east, where the coal re-appeared in the nala, though the top was not seen. Here I sank a small hole to a depth of 4 feet 6 inches, without reaching the bottom of the coal. Including, therefore, the abovementioned seam of 1 foot 4 inches, there is, at this spot, a minimum thickness of nearly 6 feet of coal. It is of fair quality, and burns well; but the lower portion contains a great quantity of iron pyrites, and even the upper 1 foot 4 inches, when burnt, leaves a reddish ash. This, however, appears to be the only drawback. Very little can be made out in the adjoining ground, but the dip is low and favourable.

About a quarter of a mile to the east in the same nala, the top of an outcrop perhaps of the same seam can be traced for at least 100 yards.

X. *Barkoi seam.*—The next spot to the west is Barkoi. Here alone have any workings taken place, and even here they have not been extensive, consisting of one small quarry. The opening made, however, is sufficient to enable a better judgment of the characters of the seam to be formed than in most of the other places mentioned.

The coal was first observed on the banks of a nala which runs from north-east to south-west, just south of the northern portion of Barkoi village. The quarry is north of the nala, and exposes the following section:—

	Ft.	In.	Ft.	In.
Earth			0	6
Sandstone			3	3
Shale (generally decomposed)			6	9
Coal, decomposed in the quarry, shaly towards the top	2	4		
Shale, variable, about	0	2		
Coal	6	0	8	6
Shale becoming sandy below.				
			19	0

The total thickness of coal is thus 8 feet 4 inches, but the uppermost 1 foot or 18 inches and the bottom 1 foot are very shaly, and there appeared to be about 6 feet of good coal. In the quarry as at present worked, there is less than this, for the upper portion is too much decomposed to be of much value, and not more than from 4 to 5 feet of marketable coal is obtained. None of the coal quarried can, of course, be equal in quality to that which would be obtained if it were mined from a greater depth below the surface. The dip is to the south-south-west, and does not appear to average more than 3°, though amounting to as much as 5° in places.

Associated rocks and geological characters of neighbourhood.
Probable extent of seam.

On the south side of the nala, massive felspathic sandstones overlie the coal. They can be traced to a considerable distance, and are well seen in another small nala to the south, which cuts deeply into them. To the north, the coal doubtless crops out close by and is lost. There is no indication of its recurrence in this direction, though the beds roll and are unsteady in their dip.

To the west, or rather south-west, down the little nala, the coal can be traced for a short distance, and about 150 yards below the quarry, north-west, Mr. Adams, the agent in charge, sank a small pit at my suggestion, and came upon coal at the depth of 7 feet; this gives a fall of about 20 feet in 150 yards; but as the direction of the nala is not quite the same as the dip of the coal, the latter being more to the south, the inclination is in reality rather greater. To the east and north-east, the coal can be traced for some distance. About 150 yards from the quarry, there is a small fault with a throw of, apparently, not more than 15 or 20 feet, striking north-west—south-east, which brings down the coal to the north-east. At least such appears to be the case, though the seam beyond is immediately covered by sandstone instead of by shale. This may be due to the decomposition of the shales in the nala bank, and to the sandstone sinking on the coal, or to local unconformity at the period of formation of the coal—a very frequent occurrence in coal measures. At the same time the seam may be different. The section thence to the east is ill seen; the nala is small and choked with blocks of sandstone; but about 200 yards beyond the fault the coal re-appears, perhaps brought up by another little break.

In a nala which passes by the southern portion of the village of Barkoi, south-east of the coal outcrop, a poor section of the beds is seen, the greater portion consisting of coarse felspathic sandstone, similar to that overlying the coal. One small outcrop of a coal seam, 6 inches thick, is met with. The beds have no distinct dip; they are, apparently, slightly inclined to the south. There is no reason for supposing the small outcrop to be in any way connected with the Burkoi seam. In all probability it is much higher in the series, and the Barkoi seam, if constant, which there appears no reason to doubt, should underlie all these beds. In fact, there seems every probability of its existing under a considerable tract of country.

Quality of coal.

The quality of the Barkoi coal is much the same as that of the others described. It is less bright than the Chenda coal, but it is undoubtedly fair fuel. It, however, contains a large proportion of iron-pyrites, more than any of the other seams, except perhaps that of Bhutaria (and this has not been sufficiently cut into to determine). The lower portion of the seam appears, however, to contain less pyrites than the upper. In the coal now extracted from near the surface, the pyrites has, in great measure, decomposed, leaving the joints of the coal lined with peroxide of iron, and a white efflorescence (? sulphate of alumina) frequently forms on the surface. Both of these tend much to injure its appearance. The coal ignites with great readiness, and burns very freely with much flame. The ash is in parts deep red, in others only reddish, and in some cases nearly white.

Despite the considerable proportion of pyrites contained, this coal does not appear to decompose rapidly when exposed. In some heaps, which have been lying on the surface exposed to the weather for two years, the coal has not split up or broken to any extent.

Mining prospects.

The workings hitherto, as I have stated, have been but small. The circumstances under which the seam occurs are, I am inclined to believe, very favourable for mining; the dip is low, and although faults occur, they appear to be of small amount. The shale and overlying massive sandstone would form a good roof in all probability. There is nearly a mile of gently rising ground between the outcrop of the coal and the hills to the south, so that, if the seam be continuous, a colliery may be worked for many years before it is likely to be necessary to sink shafts to any great depth. In this, as in all collieries, however, some preliminary exploration by boring is desirable before any large outlay in shaft sinking and erection of steam engines is undertaken.

Any coal that may exist to the north of the nala may as well be quarried as the quarries there would not affect deeper workings. South of the nala quarries would be objectionable, as if deeper workings are commenced, the quarries will tend to increase the quantity of water met with.

IX. Gogri or Hingladevi seam.—The last place that I visited to the westward was about 2 miles west of Barkoi, in the lands of the village of Gogri, and close to a small jungle shrine known as Hingladevi. Mr. Adams showed me the spot, and, at my request, set workmen to dig into it. They had reached the depth of 4 feet 10 inches from the top of the coal seam, when I saw the spot a second time, all the thickness being through coal. The excavation was continued, and beneath 9 inches of shale was found 6 inches more of coal, beneath which shale recurred, and below that again sandstone. I was informed of this in a letter from Mr. Adams, accompanied by specimens, which reached me after I had left the coal-field. I do not quite understand whether the upper portion of the seam exceeded 4 feet 10 inches or not; but there must be a seam of above 5 feet of coal. It apparently dips at a low angle to the south.

The coal appears of fair quality, though shaly in parts. The outcrop is in the bed of a small nala running between low hills, but with ranges of greater height to the south and south-east. In consequence of the unevenness of the ground, the spot is not so well suited for mining as Burkoi.

Coal at Paláchaori.

Besides all the above localities, coal is said to have been found in a well at the village of Paláchaori, north of the last described locality.[1]

Importance of the discoveries of coal seams.

The above details will, I think, serve to show that these discoveries of coal seams are the most important that have been made in India for many years, amongst all the previously known coal localities in Central India; to the west of the meridian of Jabalpur, there are but two seams, both at Mopáni, in Narsinghpur district, which exceed 4 feet in thickness. Near the Pench, within an area of 16 miles in length from east to west, no less than six (or, including Bhandaria, seven) localities have now been discovered in which seams exceeding that thickness occur; and when it is borne in mind that, with two exceptions only (Barkoi and Hingladevi), the whole of these localities have been discovered since the month of October last, and solely through the researches of Major Ashburner, I think it is only reasonable to believe that many other workable seams may still remain undiscovered in this neighbourhood, and that there is every probability that this portion of the great Sátpura coal-field equals, in mineral wealth, the coal-fields of the Damuda valley in Bengal.

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[1] Since my departure, Major Ashburner informs me that he has discovered two other places where coal occurs.

Favorable conditions for mining.

The circumstances under which the coal occurs, appear, in most instances, to be favorable to mining enterprise. The dips are very low, and, so far as a judgment can be formed from the very imperfect sections exposed at the surface, there appears good reason to anticipate that both the quality and thickness of most of the seams will be found constant, at all events over a considerable area. Faults are numerous, but the majority do not appear to be of sufficient amount to affect mining operations injuriously. It is probable that these faults will be found to decrease in number, the greater the distance from the fault bounding the coal measures to the south.

Quality of coal.

The quality of the coal, so far as a judgment can be formed by inspection, and by burning it in heaps, is similar to that of the coals of Raniganj, and other mines in that neighbourhood. It is a free-burning, non-caking coal. It is decidedly inferior to the better qualities of English coal, both on account of the larger proportion of ash and of the lower percentage of fixed carbon. At the same time, I see no reason for doubting that, for railway purposes, the Pench river coal is perfectly adequate; it is just as well suited as the Raniganj coal, with which the East Indian Railway was worked for some hundreds of miles, and I believe that for all local purposes, or for fuel for stationary steam engines, it is excellently adapted; while for the manufacture of iron, the freedom from pyrites possessed by the Sirgori seam, if found to be constant, should give that coal advantages over most other Indian coals with which I am acquainted.

Seams discovered probably distinct.

The question may possibly arise, whether some or all of the seams discovered may not be identical. Without a much closer examination of the country than it has been possible to make hitherto, it would be impossible to answer this question precisely in every instance; and, even were an exact survey made, the large area of ground covered and concealed by trap, and other formations more recent than the coal-bearing rocks, would render the tracing of each seam a hopeless task, until mining operations had advanced considerably. But there can, I think be no question that the majority of the seams are quite distinct from each other, and I have not been able, in a single instance, satisfactorily to ascertain that any seam examined was identical with one seen elsewhere.

Localities best suited for mining.

Amongst the localities I have described above, I am disposed to believe that those best suited for mining purposes are Sirgori, Bhutaria, and Barkoi; but further explorations by boring, as I have shown above, are desirable in every instance. The availability of the splendid seam on the Pench, at Chenda, depends, as I have above stated, on its continuance to the north, beneath the trap in the river. Further exploration is required at Parassia, and it is extremely desirable that the thickness of the seams there and at Bhutaria, and, above all, at Sirgori, should be ascertained at

Specimens sent for analysis.

With this report I send for analysis fair specimens of the four principal seams named, *viz.*, Sirgori, Chenda, Bhutaria, and Barkoi[1]; those from Chenda being taken from the lower 4 feet 3 inches coal, which is the best part of the seam, and which in the cutting made was least injured by surface decomposition. The specimens from Barkoi are also from the lower part of the seam, for the same reason. In comparing the results it should be borne in mind that the coal from Chenda, Bhutaria, and Barkoi, is outcrop coal, and that fuel of a superior description will, doubtless, be obtained, by mining—fuel, however, which may probably contain more sulphur and gaseous ingredients, while the coal from Sirgori is mined from 30 feet below the surface. It should also be remembered that the present specimens are small fragments, broken from various parts of the seam, for the purpose of obtaining a *fair sample* of the whole.

Climate of district.

Apart from geological conditions, the circumstances of the country are, I think, favorable for the establishment of collieries,—the country being high, the climate is cool, and well suited for Europeans, except for two or three months, during which, owing to the prevalence of jungle, it is feverish.

Supply of labour.

The population of the district is chiefly Gond. These people are indisposed to work regularly, and labour for hire may have to be imported. But *quasi*-aboriginal tribes like the Gonds, if kindly treated, are excellent labourers, and are likely to become good miners, being superior in physique to the average labourers of Central India. The miners at Raniganj belong exclusively to races allied to the Gonds, Bhonris, Santals, &c.

The immediate neighbourhood of the Pench river is fertile, and the villages are numerous; away from its banks, the population is sparse, and the greater portion of the country covered with jungle.

Camp, Betul district,
March 10th, 1866.

	Fixed Carbon.	Volatile matter.	Ash.
[1] Chenda	61	16	23
Barkoi	50·3	26	23·7
Bhutaria	49·3	26·5	24·2
Sirgori	61·6	28	10·4

List of coal seams hitherto discovered in the Pench river coal-field.

Number.	NAME OF VILLAGES.	Thickness of seam.	Thickness of good coal in seam.	Average angle of dip.	Direction of dip.	REMARKS.
		Ft. In.	Ft. In.			
I	Singori	Above 4 9	Above 4 9	5°	N.	Not yet sunk through.
II	Ditto	3 0	3 0	5°	N.	Not workable.
III	Chenda and Digawáni (Pench R.)	15 6	12 3	3°	N.	
IV	Harrai	?	?	?	?	Particulars not ascertained.
V	Rawanwára	7 0	3 4	4°	N.	Probably not workable.
VI	Ditto	?	Above 3 0	10°	N. 20° W.	Thickness not ascertained.
VII	Parassia	?	Above 5 0	?	N.	Exact dip and thickness not ascertained.
VIII	Bhandaria	15 2	7 3	10°	N. 10° W.	
IX	Bhutaria	Above 7 8	Above 5 10	5°	S.	Total thickness not sunk through.
X	Barkoi	8 6	About 6 0	3°	SSW.	
XI	Gogri (Hingladevi)	? 6 0	? 5 3	About 5°	S.	This seam may be a few inches thicker.

Note on borings *for* coal *at* Engsein, *British Burma:*[1]

By R. ROMANIS, D.Sc., F.G.S.E.

A company being engaged in exploring the post-tertiary strata at Engsein, about 6 miles from Rangoon, for coal, I took the opportunity to examine the specimens brought up.

The surface consists of sand loosely cemented together by peroxide of iron. Throughout this bed there are found nodules and bands of a hydrated peroxide of iron containing manganese. This bed of yellow-sand passes into a bed of grey sand, evidently the same before the iron in it has become peroxidized.

Below the sand is a considerable depth of a fine clay, like pipe-clay. From this one or two fragments of stone were brought up, which, I am informed, are called "boulders" by the borers.

I was puzzled to account for their presence. They are composed of a crystalline rock of comparatively small density; with a glass I observed small reddish-brown crystals like garnet. There are no traces of volcanic action in the neighbourhood so far as I know, and it is not easy to see how they could have been brought into their position. They may have been shot from some former sub-marine volcano now concealed beneath the alluvium of the delta, or they may be fragments of a meteorite. I have not yet analysed them.[2] In this bed, too, were found casts of the roots of some plant, apparently a water-lily. A thin seam of lignite, about an inch in thickness, was passed through. I shall take an early opportunity of re-visiting the borings.

I understand that a friable sandstone underlies the clay, and that this crops up to the surface at a short distance to the north, and that a new boring is about to be commenced to explore the strata below.

On Sapphires *recently discovered in the* North-West Himalaya:

by F. R. MALLET, F.G.S., *Geological Survey of India.*

Some excitement has been caused of late in Upper India by the discovery, in the region beyond the snows, of stones concerning which the most conflicting accounts have appeared from time to time. At first they were described as amethyst, or as blue quartz, subsequently as sapphire, and later on as amethyst and as sapphire again.

An equal amount of uncertainty has prevailed as to the locality from which the stones have been obtained. The discoverers, naturally enough, have not

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[1] Frequent mention having lately appeared in the newspapers of a discovery of coal near Rangoon, some information on the subject would naturally be expected from the Geological Survey I had endeavoured, officially and otherwise, to ascertain the locality of the exploration and the facts upon which it was based, but without success; so the notice (communicated unsolicited) by Dr. Romanis is very welcome. I need hardly add that it only increases our curiosity as to what *can have led to the search for coal in such ground.*—H. B. MEDLICOTT.

[2] In a later note Dr. Romanis adds—"I have analysed the so-called boulder and satisfied *myself that it is not of igneous origin, but there must be some* mistake in the account I received *of the way it was found.*"

felt particularly eager to impart their secret to the rest of the world, and have perhaps not displayed any remarkable energy in correcting such false reports as may have arisen. There appears, however, to be little doubt, now, that they are found in the neighbourhood of Padam in the Zánskár District, within the territory of Káshmir. The discovery seems to have been due to a landslip, which laid bare a new face of rock in which some of the blue stones were visible. On working into the rock large quantities were subsequently extracted. The first lots of the mineral that were brought across the snow are said to have been sold at extremely low rates, owing to the ignorance of the carriers as to their value. Now, however, the gems are fetching high prices, Rs. 85 a tolah, having, it is said, been offered at Simla, while for individual specimens considerably higher rates have been declined. It was stated some time ago that the Delhi jewellers had bought up more than two lakhs (20,000£) worth of the stones.

As it was desirable that the real nature of the mineral should be ascertained beyond doubt, two specimens, obtained at Simla, were recently forwarded to this office by direction of the Punjab Government: one of these weighs about 250 grains, the other about 110. The larger is in part transparent, and of a rich blue tint, partly bluish-white and translucent. The smaller is almost wholly of the transparent blue variety, but shades into brown in one or two spots. The physical and chemical characters of the specimens show conclusively that they are true sapphire. The specific gravity of the larger piece was found to be 3·959 and of the smaller 3·961.[1] The mineral scratches topaz; is infusible before the blow-pipe; and when fused in powder with acid potassium sulphate, and dissolved in water, yields a bulky precipitate of alumina with ammonia.

Of two other specimens, subsequently sent, which were obtained by the Assistant Commissioner of Kulu, one is a double hexagonal pyramid (probably 4P2, but with irregular angles) terminated by the basal planes. There are four or five smaller crystals of sapphire attached to, or embedded in, it. The crystal is 2¾ inches long and weighs rather more than 800 grains. It is bluish-white and translucent, with transparent blue portions irregularly mixed. The other specimen is about an inch and a quarter long and seven-eighths of an inch diameter at one end. It constitutes one-half of a double hexagonal pyramid (2P2), which has been broken across near the centre. The fracture displays a cavity of considerable size in the interior, containing two crystals of tourmaline. One of these is of comparatively large size, but showing no well-defined faces; dark-brown in colour, and semi-transparent. The other is very much smaller, but well-crystallised (∞P2. ∞R. R.), and transparent, the body of the crystal being light brown, and the termination indigo-blue.

I have also had an opportunity of examining a consignment of the gems aggregating some pounds in weight. They included, besides irregular fragments, a considerable number of crystals, one of the largest and best formed of which was a double hexagonal pyramid terminated by the basal planes (4P2. 0P.). It measured 3″ × 1¾″ × 1¼″, and, like all the others, was bluish-white and translucent, with transparent blue portions irregularly mixed. The blue parts of course constitute the valuable portion of the crystals, and are carefully cut out by the lapidaries, while the bluish-white are scarcely entitled to the name of sapphire, and would be more appropriately designated as corundum. A considerable proportion of the specimens contained small crystals of dark-brown tourmaline, which seem to be most common in the interior and near the centre of the sapphire crystals.[1]

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[1] The specimens are thinly coated in places by a white mineral (with minute botryoidal surface), which may be gibbsite, but there is too little of it for satisfactory determination; and on the surface of the larger one there are two or three minute crystals of greenish tourmaline. The presence of these minerals introduces a slight error into the above-given specific gravities, for the sapphire alone. This error, however, probably does not exceed 1 in the second place of decimals, and reduces the apparent below the true value. Although the amount of foreign matter on the smaller specimen is much less than on the other, the observed specific gravity is higher by only ·002.

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[1] Since the above was in print, the following letter has been received from the Revd. A. W. Heyde, the Moravian Missionary for many years resident in Lahul, than whom no one is more likely to receive correct information on the subject :—

Letter from the REVD. A. W. HEYDE, *Moravian Missionary, dated Kyélang* (viâ *Kangra and Kulu*), *Punjáb, the 18th April 1882.*

Owing to the fact of my being shut up by snow during the winter months, a letter from Mr. Lydekker, of the 21st of February, reached me only four days back. He writes for information regarding the blue stones which have lately been found in the neighbourhood of Lahul and sold in large quantities, chiefly by Lahulies, at Delhi and elsewhere. I have gathered what information I could.

The place from which all the blue stones which have come into the market *till now* have been taken, is, according to one informant in Padar [Padam], about half a day's journey from the top of the *Umasi Pass*, 2 or 3 kos *to the east* of the village of Machél (which I cannot find on my maps). According to another informant, the place is reached best from the top of the Pentse La, between Zánskár and Rangdum. From the Pentse La you have to cross the same range which is crossed by the Umasi, when you find the spot on the *southern* slope, after having descended for a short distance. This way is only known to the Zánskár people living near the Pentse La. The exact spot is situated as high as the line of perpetual snow where vegetation has ceased. Its surface is a dark-brown earth, followed by a stratum of a white stuff, resembling, as my informant said, *bul* (soda), which is found in the Nubra valley.

In this white stratum regular crystals or shapeless bits, large and small, of the blue stone are found singly and can be taken out " like potatoes " without any instrument. But when this white layer, which does not appear to be thick, is worked through, more or less solid rock is met, which is *also blue*, and from which bits can be taken only with instruments. This information I received from different people, two of whom professed to have seen the place. How far all this may be true, I cannot tell, though I have no reason to doubt the information as a whole.

Very interesting is the statement made to me, that this place is not the only one where these stones are found under similar conditions. In the immediate neighbourhood of the spot described, the people know of two others, in one of which the blue stone is found not below the ground but in horizontal seams of a large rock, but also, as it appears, surrounded or embedded in that white stuff. Another spot where this stone is said to exist is from 50 to 100 miles or more to the east, or rather south-east, in the *same range*, above the monastery of Bardan in Zánskár (a village near by is called Pipcha). And only yesterday I heard that a shepherd of Lahul *thinks* he has seen the same stone here in Lahul high up in the hills on the right side of the Chandra Bhaga, about two marches upwards from Tri Lok Náth; in this case, also, it seems, at the height of the snow line. This, if true, would not be in the main range, but in a branch of it. In Padar these stones were first found, as is said, by a *shikári* about two years ago. Only last year he and other people of Padár found out that they had some value, beginning to sell them to traders and several people of Lahul, at one rupee a seer. As yet the Maharája's people know only of that one place where the stones are found; the others are kept secret by the people for fear of hardships which might follow a disclosure. As the stones are found at so great a height, partly in well nigh inaccessible spots, the Maharája's guards who have been stationed to watch that one place from a distance are unable to prevent the inhabitants from taking out and selling stones still. In Zánskár large quantities of them are still in the hands of the people, amongst which there are said to be some very perfect and large crystals—one of them is said to be a foot in length.

I myself have not made an object of buying such stones, but have seen different bits of them. The upper end of what seemed to have been a regular crystal, having been broken, had *two* broad sides and *four* small sides. Several shapeless bits were covered with a whitish crust consisting as it were of minute quartz or lime crystals, the crust adhering very firmly. Others were irregularly covered with well-formed small crystals.

The thick end of another broken larger crystal looked for about an inch like topaz, the colour being that of a deep-coloured sherry wine, quite transparent, the two colours (blue and yellow) running gradually into each other.

I forgot to mention that in the localities in Padar where the stone is found, the common pebble in large and small crystals abounds.

Jewel merchants from the plains pay here at present as much as Rs. 30 for one tola of the blue stone if the colour is pure. I further forgot to mention a report, according to which also stones of a *red* colour have been found in the same localities.

Notice of a recent Eruption *from one of the* Mud Volcanoes *in* Cheduba.

The following letter from the Commissioner of Arakán to the Government of Burma, relating to a fiery eruption from one of the mud volcanoes in Cheduba, is published in continuation of similar records[1] :—

From COLONEL E. B. SLADEN, *Commissioner of Arakán, to the Secretary to the Chief Commissioner, British Burma, Rangoon. Dated Akyab, 4th January 1882.*

I have the honour to report a rather interesting phenomenon in connection with the shock of earthquake which was felt at this station on Saturday morning last, the 31st December.

2. The vibrations commenced at about 7-55 A.M., and were continued at intervals from ten to fifteen minutes.

They were not severe, but doors and windows of houses rattled; furniture was made to undergo a seè-saw movement, and pendulum clocks in some instances stopped.

3. I was myself at the time on board the S. S. *Mahratta*, off the mouth of the Sandoway river, and the point of interest in relation to the earthquake is, that, simultaneous as regards time with its occurrence at Akyab, we were eye-witnesses of one of those violent volcanic eruptions which have already been observed to take place on some of the islands lying off this coast during the great earthquakes of 1833 and 1839.[2]

4. In the present instance, the eruption occurred in one of the extinct volcanoes near the southern extremity of Cheduba Island.

As we were lying at anchor at the time off the mouth of the Sandoway river, we must have been about 30 miles from the scene of the volcano; but even at this distance a dense column of smoke and broad massive flames of fire were seen to rise, as it were, from the horizon, and stretched far up into the distant sky.

Viewed even by daylight, the sight was a magnificent and impressive one, owing to the great volume of flame and the immense height to which it rose. Dr. McClelland, writing of the eruption in 1833, says that the flames issued to the height of *several hundred feet*; and the description given in Silliman's Journal of a similar eruption in 1839 is to the effect that "fire mingled with smoke and ashes rose to a *fearful height.*"

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[1] Vols. XI, p. 188; XII, 70; XIII, 206; XIV, 196.

[2] Vol. XI, pp. 197, 206.

5. In these two instances the observers were within 3 or 4 miles of the eruptions. In the present instance, we were 33 miles in a straight line from the scene of the eruption, and at that distance, the flames, as seen by us, appeared at times to reach half-way up from the horizon to the sky, and to have a lateral (apparent) breadth of from 30 to 40 feet.

They continued to issue forth with greater or less effect for about 15 minutes, and then suddenly disappeared; but the smoke, which had risen in a long straight column, formed itself into a vast black canopy, which hung like a cloud in the sky, and was visible for hours after the eruption was at an end.

6. I may mention that the high land of Cheduba was quite visible from where we were, and that bearings, taken at the time, indicated the scene of the eruption to be the extinct volcano known locally as the "Naga Dwen."

ADDITIONS TO THE MUSEUM.

	Donors.
A collection of vertebrate fossils from Perim Island (see above, p. 104).	Captain. Searle, *Supdt. of Marine, Calcutta.*
Mammalian bones from pleistocene beds of the Jamna valley, in the Bánda district.	Mr. John Cockburn.
A slab of shale with plant-impressions from the Karharbári coal-field.	W. G. Olpherts, C.E.
Two blocks of English patent fuel.	The Madras Railway Co.
A block of cupriferous gneissose schist from the Báraganda copper mine, Hazáribágh.	Mr. N. Kenny
Specimens of crude asphalt, 'boiled pitch,' and 'glance pitch', from Trinadad.	Dr. O. F. Beichmann.

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Karrer, Felix.—Der Boden der Hauptstädte Europa's (1881), 8vo., pht., Wien.

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Zigno, Achille de.—Flora Fossilis formationis Oolithicæ. Vol. II, pt. 3 (1882), 4to. Padova.

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Annales des Sciences Géologiques, Vol. XII, No. 1, and XIII (1881), 8vo., Paris.

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Annals and Magazine of Natural History, 5th Series, Vol. IX, Nos. 49-51 (1882), 8vo., London.

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Bibliothèque Universelle. Archives des Sciences Physiques et Naturelles, 3me. Période. Tome VI, Nos. 10—12 (1881), 8vo., Genève.

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Botanisches Centralblatt, Band VIII, Nos. 8 and 10—12, and IX, Nos. 1—8 (1881-82), 8vo. Cassel.

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Journal of Science, 3rd Series, Vol. IV, Nos. 97—99 (1882), 8vo., London.

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April 6th, 1882.

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